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FEVER:

A STUDY IN MORBID AND NORMAL PHYSIOLOGY.

BY

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ADVERTISEMENT.

The following paper gives the results of experiments made, partly at the expense of the Smithsonian Institution, by Dr. H. C. Wood, of Philadelphia, in 1876 and 1877, to determine the nature and cause of fever.

The memoir was submitted to the Institution in 1878 and referred to a commission consisting of Dr. S. Weir Mitchell and Dr. J. J. Woodward, and on their recommendation it was accepted for publication in the Contributions to Knowledge.

SPENCER F. BAIRD,
Secretary of Smithsonian Institution.

Washington, October, 1880.

PREFACE.

THE present memoir is the outcome of labor, which has occupied during many years all the hours that could be spared from pressing professional engagements. Like other works, which have grown up rather than been fully conceived of in the beginning, it has taken a final form somewhat different from that which originally shaped itself in the author's mind, having been especially modified by the hand of death laid upon those who were to have been co-workers to the end.

It was intended that the memoir should be a complete discussion of the subject on which it treats; including in its scope the chemistry of fever and the relation of the febrile state to ingestion and elimination. I am not a practical chemist, but Dr. Horace Hare was to have had charge of the chemical portion of the research, which would have been published under our joint names. After some months spent in devising, preparing, and testing apparatus, Dr. Hare was overtaken by the malady which ultimately caused his death. This deranged all our plans, and resulted in my continuing alone the share of work originally allotted to me.

It is, perhaps, allowable for me in this place to pay a brief tribute to the memory of one who took an active part in preparing the groundwork of the present research. Fitted by natural endowments and by careful scientific training both in this country and abroad, Dr. Horace Hare, had he lived, would have proved himself worthy to bear the name of his grandfather, Prof. Hare, who so long gave lustre to the chemical chair in the Medical Department of the University of Pennsylvania. By industry and originality he was fitted to shine as an investigator; by his remarkable personal winsomeness and his gifts as a public lecturer he was destined to have become a great teacher of his favorite science—had not death ended all. To him the author owes, not only memories of many hours spent most pleasantly and instructively, but gratitude for suggestions, for manifold aid, given at a time when the task, now completed, seemed hopeless in its complexity and magnitude.

I also desire to acknowledge great personal indebtedness to Dr. B. F. Lautenbach, whose young life was put out by the same fatal disease that ended the career of Dr. Hare. First as a pupil and afterwards as an assistant, Dr. Lautenbach was

associated with me for years, and did a large amount of work upon the present research; indeed, at one time, it was proposed that the paper should appear under our joint names. Circumstances, however, led the doctor away from Philadelphia, and his work was generously placed at my disposal. He certainly performed some hundreds of hours' labor as my assistant, and was of much service in the discussion of plans and methods. In only one experiment, however, reported in the Memoir did I not myself take part, and almost all of the final thermometrical readings were made by myself, except in the case of the fever experiments, when I usually allowed my assistants to carry on the work through the alternate nights. Most of this night-work was personally superintended by Dr. Lautenbach, although I am under obligations to Drs. G. Evans Abbot, Jno. Marshall, Edward T. Reichert, W. W. Jaggard, and others for aid, without which the research could never have reached completion. Almost all of the calculations were originally made by myself, but were revised, and indeed recalculated by Mr. T. D. Dunn and Dr. W. W. Jaggard. The few carbonic acid examinations reported were made by Drs. Abbott and Marshall.

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FEVER.

A STUDY IN MORBID AND NORMAL PHYSIOLOGY.

CHAPTER I.

THE ESSENTIAL SYMPTOM OF FEVER.

In approaching a physiological or pathological process for the purpose of studying its mechanism and nature, its essential symptom should, if possible, be first determined as a guide in the unravelling of the mysteries of the process. Fever has been defined to be "an acute derangement of all the functions"; this it certainly is. Yet the definition gives to the mind no idea of the phenomena of fever. When these are analyzed, it will be found that the most important of them are capable of being grouped in four sets: acceleration of the heart's beat, and disturbance of the circulation; nervous disturbance; elevation of bodily temperature; disturbance of nutrition, including secretion.

It is evident that these four symptomatic groups may have one of two relations: one condition may be the cause of the other, or they may all be simply the result of a common cause. If it can be found by experimentation that each of these conditions can be singly provoked without the remaining conditions being at the same time evolved, it is at once rendered exceedingly probable that the relation between these conditions is not causal, *i. e.*, that no one condition is the cause of the others, and that their interdependence does not extend beyond their being the result of some common cause. On the other hand, if experimentation shows that one of these symptoms or conditions is capable of producing the other conditions, the natural inference is that this is a primary condition, and is really the cause of the others, which are, therefore, secondary states or symptoms of fever.

The nervous disturbances of fever may be summed up as paresis or convulsions, stupor, coma, delirium. Clinical experience abundantly demonstrates that these do not necessarily induce high temperature or accelerated circulation. The proof of this is so evident that it is not necessary to do more than to allude to it. Again, it is equally sure that increased activity of circulation is not sufficient to induce the high temperature of fever. It is, indeed, true that increased activity of blood movement has some effect upon the animal heat, but this effect is, comparatively speaking, slight. By means of excessive exercise, or by the use of certain

drugs, the circulation can be excited much beyond the point that it reaches in fever, but under these circumstances the elevation of temperature never approaches that of high fever.

Disturbances of nutrition, including secretion and excretion, are certainly capable of causing fever, but that such disturbances are not always the cause of the febrile state is shown by the circumstance that fever may be generated in the normal animal by external heat without a previous appreciable alteration of secretion or nutrition. It would indeed appear that derangement of nutritive functions is frequently a secondary and not a primary phenomenon of fever.

From the considerations just brought forward it would appear that such disorders of circulation, innervation, or nutrition as constitute the gross symptoms of fever are not essential to fever, *i. e.*, capable of producing the other phenomena of the febrile state, and that if any one fever symptom be the cause of the other fever symptoms, it must be the elevated temperature.

When we desire to heat any inorganic body we do it by applying to it heat, but the living animal body has power of resisting the absorption of heat by means so well known as not to require consideration here. This power is, however, limited, and we are able to heat the animal provided the external warmth be sufficient and be applied with sufficient persistency.

The following series of experiments was performed to determine the effect of heating the animal body. In the first two trials natural heat was employed. A box was constructed rudely with a slanting glass lid, like a miniature green-house. It was simply placed upon a brick pavement, when used, in such a way that the sun could exert its fullest power upon it. In the other experiments artificial heat was employed.

Experiment 1.

Exposed a two-thirds-grown rabbit in a box covered with glass.

1 P. M.—Temperature in rectum, 104°.5 F. Temperature of box, 120° F.

1:15 P. M.—Temperature, 106°.5. Respiration very hurried.

1:30 P. M.—Temperature, 109°.5. Has convulsive attacks, in which he jumps, and kicks with hind legs with great fury.

1:45 P. M.—Temperature, 112°. Seems very weak and relaxed; breathing 220 a minute. Lies on side, with every now and then the attacks alluded to; slobbering greatly.

2:10 P. M.—Temperature of box, 120°. Rabbit on side, exceedingly weak, gasping; squealing faintly at intervals.

2:15 P. M.—Temperature, 114°.5. Perfectly unconscious; lies relaxed and motionless on the cool ground in the shade.

2:20 P. M.—Only gasping at long intervals; heart still beating, although laboredly, and somewhat irregularly, yet pretty steadily, and with some force.

2:21 P. M.—Dead.

Autopsy.—Heart: right side and left auricle full of blood; left side containing blood, not contracted. The heart made a few very imperfect and feeble attempts at beating when it was cut across. Blood coagulating with great rapidity and firmness; alkaline. Brain not congested. Muscles all failing to show the slightest sign of contraction under the strongest faradic current, except some of the leg muscles, which contracted very feebly, and only when the current was very intense.

Experiment 2.

Two-thirds-grown rabbit. Put in the box at 11:30 A. M. Rectal temperature, 104°.5.

12 M.—Rectal temperature, 109°. Temperature of box, 112°.

12:25 P. M.—Rectal temperature, 110°.5. Rabbit weak, slobbering a great deal; breathing with great rapidity.

1:15 P. M.—Rabbit conscious, lying quietly on his side; not slobbering; breathing not nearly so rapid, but deep and labored. Rectal temperature, 111°.5.

1:35 P. M.—Rabbit found dead. Rectal temperature, 112°.

Autopsy.—Heart: left ventricle empty, very firmly contracted, with a very evident white spot at apex. Galvanic (induced) current very strong, giving rise to no muscular movements whatever, either of heart or voluntary muscles. Blood coagulating slowly and imperfectly; reaction neutral, or at least so feebly alkaline as to be uncertainly so. Muscular reaction very decidedly acid. Spinal cord not congested. Right side of heart gorged with blood.

Experiment 3.

A large adult rabbit.

12:11 P. M.—Rectal temperature, 105°. Just put in box, whose temperature is 130°, heated by very hot brick flues, on which the rabbit lies.

12:15 P. M.—Rectal temperature, 107°. Breathing excessively hurried.

12:17 P. M.—Rectal temperature, 109°.

12:21 P. M.—Rectal temperature, 111°. Had a moment since what was apparently a convulsion, and has had numerous convulsive twitchings since. Appears semi-unconscious.

12:25 P. M.—Dead. Temperature in abdomen after death, 111°. Respiration ceased some time before heart. The thorax was opened, and the heart was felt by the finger to be pulsating. On more complete exposure, the heart was seen to be very distinctly pulsating, and gradually becoming filled with dark blood. The heart was punctured, and blood allowed to escape; it made one or two pulsations, and then at once became rigid. After this the diaphragm was tried with the galvanic current, and responded to it. The muscles of the hinder extremity did not respond, those of the front legs did. Peristaltic action of the intestines was moderately active when the body was opened, and on galvanic excitation became very active.

Experiment 4.

A moderate-sized dog.

1 P. M.—Put in the hot box.

1:15 P. M.—Rectal temperature, 106°.

1:30 P. M.—Rectal temperature, 110°.

1:40 P. M.—Rectal temperature, 110°.75. Just dead.

Autopsy.—As soon as respiration ceased, the body was opened. Heart still beating, gorged with dark blood. Veins full of dark blood. Blood on being shaken in test-tubes rapidly clotting, and slowly changing its color to an arterial hue. The vessels were carefully examined; no clots were found in them.

Experiment 5.

An adult pigeon.

11:40 A. M.—Rectal temperature, 109°. Just put in box; the temperature in box, 130°; besides, the pigeon was in direct contact with the very hot brick flue.

11:45 A. M. Respirations very weak.

12 M.—Has been unable to stand for some time; has been semi-unconscious. Just had a convulsion, followed by persistent opisthotonos.

12:2 P. M.—Anal temperature, 120° ?. (My thermometer did not mark higher than 120°, to which the mercury rose; the hand could hardly bear the heat of the flesh.) Dead. Respiration certainly

ceased before the heart's action. Rigidity came on almost before heart ceased beating. Thorax opened as soon as heart ceased action. The heart was found rigidly contracted like a board. Muscles acid.

Experiments 6, 7, 8, 9, were the counterparts of Experiment 5.
In Experiment 10, a cat was employed. The result was as follows:—

EXPERIMENT 10.

12:16 P. M.—Temperature of box, 130°.

12:35 P. M.—Temperature of box, 130°. The cat ever since it was put in the box has been struggling violently and savagely, and for the last five minutes has been evidently growing weaker, but perfectly conscious. Just seized with a sudden tetanic convulsion, which instantly arrested all respiration, and persisted with absolute rigidity for about five minutes (not by actual timing). When the cat was taken from the box the pupils were widely dilated, the heart beating strongly and regularly. She was plunged into cold water, but never made an effort at breathing, although perfect relaxation of the muscles soon came on. The body was opened: heart found to be still beating and distended with blood; after a considerable time it was seen to gradually stop beating, and the left side contracting expelled all the blood from it, and became rigid. The diaphragm responded, though somewhat feebly, to the galvanic current fully fifteen minutes after respiration had ceased.

These experiments suffice to show that in animals heating the body artificially produces disturbances of circulation and of innervation similar to those present in ordinary fever. In man the phenomena of sunstroke, or, as I prefer to call it, thermic fever, show that exposure to external heat may produce all the symptoms of the febrile state. The following description of the symptoms present in that disorder, given by Dr. Bonnyman (*Edinburgh Med. Journal*, 1864), shows how precisely they agree with those of ordinary severe fever.

"Where premonitory symptoms show themselves, they are sometimes well marked. Those usually observed are—inaptitude and disinclination for any exertion, drowsiness, or a desire to sleep, vertigo, headache, and slight confusion of ideas; the patient feels weak, sighing frequently; the appetite is gone, thirst is increased, and the bowels are constipated; the symptoms become aggravated, and the patient either passes into the state of profound coma, or symptoms of the first or progressive form of the malady are complained of, viz, distressing headache, with a feeling of weight and heat in the occiput, tightness, distention, and throbbing in the forehead and temples, anxiety at the præcordia, nausea, and a disposition to vomit. A sensation of sinking or of insupportable weight, or uneasiness, is referred to the pit of the stomach, and a feeling of horror or of impending calamity, with a tendency to weep, is experienced. The breathing is natural, or slow and sighing. The face is generally natural or somewhat flushed, eyes bright, pupils either natural or somewhat contracted. The skin is very hot and dry; the pulse is full and accelerated, tongue white, thirst intense, bowels confined, the urine suppressed. If these symptoms persist, tetanic convulsions suddenly appear, and the patient lapses into the second or severe form of the disease."

After death from thermic fever the condition of the blood so closely resembles that seen after a malignant fever as to have caused various skillful physicians to

believe that the symptoms of sunstroke are due to the presence of a poison in the blood.[1]

That high temperature is capable of causing most fatal nutritive disturbances of almost every tissue is therefore shown not only by experiments upon the lower animals, but also by the natural (if the expression be allowable) experiment of sunstroke upon man. The peculiar odor and the offensive perspiration of thermic fever in man, the altered or suppressed urine, the frequent watery, exceedingly offensive, involuntary passages, the broken-down crassis of the blood found after death, are all of them important witnesses of the profound influence excessive temperature has upon the general nutrition.

Without occupying more space it may be claimed that by the evidence brought forward the following proposition has been demonstrated:—

External heat applied to the body of the normal animal, so as to elevate the temperature, produces derangement of the functions of innervation, of circulation, of nutrition and secretion, similar to those seen in natural fever; the intensity of the disturbances being directly proportionate to the rise in temperature.

Bearing closely upon this proposition are various experiments that have been made as to the effect of external heat upon the brain and heart when applied directly to them.

There is no difficulty in applying heat directly to the brain of the cat and rabbit by surrounding the head with a double bonnet of india-rubber, or, as I have used, of pig's bladder, and allowing hot water to run through this. Vallin is, so far as I know, the only observer who has made any such experiments. It is evident that there are two points especially to be determined in this inquiry: first, How do the symptoms produced compare with those of ordinary sunstroke? second, What is the temperature at which the functional power of the brain is lost? In only two instances did Vallin succeed in causing death by the hot-water bonnet, and in neither of these cases was any attempt made to measure the temperature of the brain. The symptoms are not described by Vallin as closely as is desirable, but appear to have been insensibility—whether coming on gradually or suddenly is not stated—with convulsions.

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[1] It is perhaps allowable here to notice a criticism of Prof. J. J. Picot (*Leçons de Pathologie Générale.* Les Grands Processes Morbides. Tome I. Paris, 1876, p. 35).

"Sans doute aussi, en 1863, H. C. Wood (cité dans 'Revue critique du mechanisme de la mort par la chaleur extérieure,' par le docteur E. Vallin. *Arch. Gén. de Méd.*, 1871:) a prétendu que chez les animaux qui succombent à la suite de l'exposition à une température excessive, on trouve le sang acide, et cette assertion a été reproduite par Obernier en 1867; mais les expériences sur lesquelles ces auteurs ont appuyé une semblable constatation manquent complétement de base scientifique, et, je le pense avec M. Vallin (*loc. cit.*), il n'y a pas lieu d'en tenir compte."

In 1863 I had made no experiments on animals. When in 1872 I did make such experiments, I wrote simply, "that the alkalinity of the blood was impaired." I had reported in 1863 cases of sunstroke, in which among other new observations I had found the *blood acid at the autopsies* performed two or three hours after death. That the acidity was present during life I did not assert, and do not know; but of its presence at the autopsies there can be no mistake. Very possibly it was the result of chemical disintegration of the blood commenced during life, but not reaching the point of acidity until after death.

My own experiments with the hot-water bonnet are as follows:—

Experiment 11.

A full-grown rabbit. Rectal temperature 102°.5 F.

Time.	Temp. of Water.	REMARKS.
12:11 P. M.	140° F.	
12:49	175	Puffiness and great swelling of the scalp, with very hurried respiration and exceedingly rapid pulse, with violent struggles, constitute the only effects as yet produced.
12:51	175	A sudden, severe convulsion, followed by a state of semi-unconsciousness.
1:04	150	Rectal temperature, 104°.5 F.
1:10	140	Lies quiet, semi-unconscious; but the corneæ are very sensitive.
1:15	180	Convulsions.
1:20		Died in a stupor, a gradual deepening of the previous semi-unconsciousness. The respiration ceased before heart's action.

Autopsy.—Skull opened instantly after death, just sufficiently to allow a thermometer to be plunged in the brain; it indicated 117° F. The heart was soft and flaccid; the right side full of blood, the left empty. The muscles responded well to galvanic stimulus, but rigor mortis set in in a few minutes.

Experiment 12.

A full-grown rabbit.

Time.	Temp. of Water.	Rectal Temp.	REMARKS.
12:38 P. M.	190° F.		
12:50	140	103°.75 F.	
1:05	135		
1:15		104.25	Pupils not contracted.
1:20	174		
1:30			Before this there have been struggles, apparently semi-convulsive, and contracted pupils. Now a true convulsion, followed by unconsciousness and complete relaxation. The breathing is accompanied by fine, sonorous *râles*.
1:50	150	106	The rabbit has lain for some time in a perfectly comatose state, with occasional convulsions. The hot-water bonnet was now removed from the head, and cold water poured over the latter; almost immediately the animal showed signs of recovering, and after awhile did so perfectly. The next day, excepting in regard to the local trouble in the scalp, etc., the rabbit seemed well.

Experiment 13.

A young, half-grown cat. The hot-water bonnet was adjusted to its head, and the water allowed to run through it.

Time.	Temp. of Water.	REMARKS.
11:15 A. M.	162° F.	
11:25		Cat has had several convulsions not preceded by signs of nervous disturbance, coming on suddenly and followed by insensibility, with partial anæsthesia of cornea.
11:40	140	
11:41	162	
11:55	170	There have been repeated convulsions, during which pupils would dilate some, although the eye was in the full blaze of sunlight. Almost constant convulsive trembling, affecting very markedly even the eye-muscles. The cat is all the time absolutely unconscious. Cat died at 11:57; the respiration ceasing at least four minutes before the heart ceased to beat. On opening the body the right heart was gorged with blood, and, on being cut, the ventricle pulsated again. The brain was opened as soon as possible after death. Its temperature was 113° F. The muscles responded to galvanism apparently not so actively as normal, and *rigor mortis* came on in about fifteen minutes (not timed with watch) after death.

Experiment 14.

A very large, powerful tomcat was used, and bladder fitted to head at 10:30 A. M.

Time.	Temp. of Water.	Remarks.
10:35 A. M.	175° F.	
11	140	Very hurried breathing.
11:30	180	
12 M.	160	Cat is now unconscious: the unconsciousness came on in a very short space of time, but not with absolute abruptness; no convulsions; respiration slower.
12:15 P. M.	175	Cat just dead. The respiration certainly ceased before the heart some seconds, or probably a minute or two. No convulsion.

Autopsy.—Brain opened instantly after death. The thermometer plunged directly into the substance rose above 114° F.; when placed, however, so as to be in contact with the inside of the skull, it marked 115°. There was decided, but not extraordinary, congestion of the brain.

As these experiments are painful ones, I have not repeated them further. They seem sufficient to establish the following conclusions: *First.* A temperature of the brain of from 113° to 117° F. is sufficient, if maintained, to produce death in a short space of time in mammals by arrest of the respiration. *Second.* That the chief symptoms induced are insensibility and convulsions, preceded by exceedingly rapid respirations and action of the heart, and unaccompanied by any general rise of temperature. *Third.* That these symptoms come on very quickly in all cases, at times with absolute abruptness.

The resemblance of these symptoms, induced by the local application of heat to the head, to the nervous phenomena of sunstroke, is very striking, both in regard to the symptoms themselves and also to the suddenness of their onset. A reference to the account of the exposure of cats to a general high heat, will show that in these animals the nervous symptoms are much more sudden and severe than in rabbits; in fact, approaching what is seen in man. The experiments just detailed demonstrate that a temperature of 113° to 114° F. is fatal to the brain of the cat, whilst, at least in some cases, that of 117° F. is required to destroy the vitality of a rabbit. The nervous system of the cat is much more excitable, and much more impressible, than that of the rabbit, and consequently feels the abnormal temperature more acutely. The brain of a man is much more highly organized, and no doubt correspondingly more sensitive, than that of a cat; and if a temperature below 113° F. be fatal to the brain of a cat, whose normal temperature is 102°.5 F., it seems very certain that the temperature of some cases of insolation (113° F.) is sufficient in itself to cause death in man, whose normal temperature is 99° F.

In connection with the above experiments, I have performed others to determine whether, when heat is applied to the head, coma is developed at the same temperature as it is when the whole body is heated. In these the hot-water bonnet was applied to the head of the animal.

Experiment 15.

A full-grown cat.

Time.	Temp. of Water.	Remarks.
12 M.	130° to 170° F. during the hour.	
1 P. M.	140	Cat has been for some time very quiet, evidently semi-comatose; at times arousing herself. Pupils moderately contracted.
1:15	180	Cat was so comatose that an attempt was made to open the head. The first incision was not noticed; but the second aroused her.
1:30	180	The pupils have been strongly contracted, and cat quiet and semi-comatose. Suddenly pupils at once dilated widely, and a severe convulsion came on. This was so severe that I think the cat would have died in it. In the midst of the fit, however, the skull was opened and the thermometer plunged into the brain. It indicated 108° F.

Experiment 16.

A young kitten.

Time.	Temp. of Water.	Remarks.
1:40 P. M.	170° F.	
1:55		Kitten has been semi-comatose, with strongly contracted pupils, for some time. Suddenly its pupils dilated, and a general epileptiform convulsion, commencing in the muscles of the jaw, set in. In the midst of this the thermometer was plunged into the brain. It indicated 107°.5 F.

The only objection of any force which I can imagine capable of being raised against the conclusion drawn from the previous experiments is, that the results were not really due to the immediate action of the heat, but to a determination of blood to the head and consequent congestion of the brain.

The want of validity of this objection is apparently demonstrated by the following facts:—

1. Sudden epileptiform convulsion is not generally the result of congestion of the brain.

2. Opening the skull through the longitudinal sinus, although necessarily affording immediate relief of any existent congestion, did not stop the convulsion.

3. Abstraction of the heat by pouring cold water over the head, sufficed to produce immediate cure.

It having been proven that the local application of heat to the brain will produce the cerebral phenomena exhibited when the brain reaches a febrile temperature, it is next in order to study the relation of the heart to fever heat. I have made no experiments upon this subject, such having been rendered unnecessary by an admirable paper by Dr. T. Lauder Brunton (*St. Bartholomew's Hospital Reports*, vol. vii.). In this memoir it is shown that when the cut-out heart of a frog is exposed to a rising temperature, the cardiac pulsations constantly become more and more rapid until a heat limit is nearly reached, at which the action of the heart ceases. The increase in the rapidity of the movements of the heart is not in direct relation to the increment of temperature; at first the increase of movement is slow, but the rapidity of the increase becomes more and more rapid as the temperature rises until the maximum rate is reached. Panum has found that the cut-out heart of the rabbit responds to heat in the same way as does that of the frog, and Brunton has experimented by bringing the rabbit profoundly under the influence of chloral, and then surrounding him with a jacket of hot water. These

experiments of Brunton are of course completely parallel with those in which I exposed animals in hot air; in both instances there was a great rise in the rapidity of the cardiac action.

It is of course impossible to experiment directly upon man, but the brain and the heart of man must be subject to the same laws, so far as regards such forces as heat, as are the same organs of other animals. It is simply inconceivable that what has been proven as true of the lower animals is not true of man. Moreover, we have very direct evidence that heat does affect the organs of man as it does those of animals.

Thus we have an elaborate study on the action of fever heat upon the pulse of man, by Dr. C. Liebermeister, who analyzed the records of 280 cases of acute disorder not directly affecting the brain or heart, accompanied by a rise of temperature, and mostly observed by himself. The following table represents the minimum, maximum, and mean:—

Temperature (Centigrade),		37°	38°	39°	40°	41°	42°
Pulse	Minimum,	45	44	52	64	66	88
	Maximum,	124	148	160	158	160	168
	Mean,	71.6	88.1	97.2	105.3	109.6	121.7

There are so many factors entering into the causation of increased action of the circulation in febrile diseases, that it is to be expected that the minimum and maximum will not obey any fixed law, but in a very large number of observations the action of the general cause of the increased pulse-rate becomes manifest, and the table shows with what great regularity the pulse rises with the temperature.

When these clinical studies are placed in conjunction with the experiments of Lauder Brunton, they show that elevated temperature acts directly in increasing the pulse-rate, and that it is apparently capable of producing all the circulatory phenomena of fever. Consequently, the following proposition may be considered as demonstrated: Heat applied locally to the brain or to the heart produces in the functions of the organ those disturbances which are familiar phenomena of fever, the intensity of the disturbances being directly proportionate to the excess of heat.

And if heat be the cause of the symptoms of fever, and if the propositions just stated be true, the withdrawal of the heat should be followed by a subsidence of the symptoms. It is plain, however, that if the heat have persisted too long it may have wrought permanent alteration in the nervous system. Hence the withdrawal of the heat must be sufficiently early to be a fair test of the truth of the conclusion reached by *a priori* reasoning.

The following experiments were performed to determine the results of an early withdrawal of heat.

Experiment 17.

A young rabbit was put in a glass box set in the sun; in twenty minutes he was apparently totally unconscious, having passed through all the ordinary symptoms. He was now taken out, and put in a bucket of water. The temperature of his body rapidly fell to the normal, that of the water rising two degrees, and consciousness was restored at once. He was very weak, but in a few minutes was able to walk some, and the next day was as well as ever.

2 March, 1880.

Experiment 18.

A pigeon of full age, with rectal temperature 108°.5, was placed in a box (130° F.) at 11:42 A. M.

At 12 M. it had a convulsion, followed by persistent opisthotonos, with complete unconsciousness, which indeed had been nearly complete before the convulsion.

12:2 P. M.—The pigeon was taken out, utterly unconscious, and at one time I thought it was dead; there were only a few gasps at long intervals. I plunged it into a tub of cold water, and kept it there. Its respiration slowly improved; but after it had been in some three or four minutes it had a violent convulsion, after which for a while it again appeared to be dead. It however slowly got better again, and in about fifteen minutes was taken out of the water and put in the air. It was now perfectly conscious, and breathing slowly and regularly, but was not able to walk. In two or three minutes it was able to push itself rapidly forward with its feet, on its breast, but was unable to raise its body from the ground. Its rectal temperature was 100°. It was now left in a basket at 1 P. M., apparently improving.

At 2 P. M. it was found dead, still warm. I saw the body at 4 P. M. There was general rigidity, and the blood was not coagulated anywhere.

Experiment 19.

A full-sized pigeon.

Time.	Temp. of Box.	Rectal Temp.	Remarks.
11:40 A. M.	120° F.	105° F.	
11:48	120	112	
11:55	120	117	The pigeon had previously struggled violently, but its struggles were apparently voluntary. It was so weak as not to be able to walk, and was now taken out of the box. It was unable to stand at all. 12:8 P. M. the rectal temperature 112°.5; pigeon is now able to push itself along, although not to stand. 12:30 P. M. pigeon apparently all right, but not disposed to fly, and its feathers seem ruffled. Pigeon died some time between 2 and 5 P. M.

Autopsy made twenty-four hours afterwards showed that the blood was fluid, and very dark.

Experiment 20.

An adult pigeon. Rectal temperature, 109°.5.

At 12:29 P. M. it was put in hot air chamber.

12:39 P. M.—Rectal temperature, 112°.

12:53 P. M.—Rectal temperature, 117°.5. Bird lying on back and side, apparently dying. It was plunged in cold water for several minutes, and when taken out its rectal temperature was 109°.5. It was unable to make any effort; with very irregular, jerking breathing, so that I momentarily expected it to die. It was not again put in water.

2 minutes (after taking out of water).—Temperature 107°.

3 minutes.—General condition growing worse.

10 minutes.—Reviving. Able to push itself along.

12 minutes.—Temperature 101°. On application of galvanic current, muscles respond well.

25 minutes.—Although pigeon has been in a warm place, its temperature is 96°.

2 hours.—Pigeon much better; lies quiet all the time, but can walk, though constantly falling; still, is better. It has been dry and in a warm place for two hours, but its temperature is only 100°.

3 hours.—Left as before.

5 hours.—Found dead, cold, and rigid. Blood as first taken out dark and fluid, but on standing in a test-tube forming into a firm coagulum.

These experiments certainly show that in the lower animals the abstraction of heat by external cold, after the animal has been artificially heated, is followed at once by the subsidence of the symptoms, provided that the high temperature has

not been continued so long as to permanently damage the tissues. In Experiments 18, 19, and 20, it is remarkable that, although the injury wrought was sufficient to cause death, yet the peculiar nervous symptoms all subsided upon the withdrawal of the excessive heat.

I have had two opportunities of performing upon men under very favorable conditions experiments entirely parallel to those last detailed.

The first of these was upon the person of a burly Scotchman, who was carried into the Centennial Hospital on a hot July day in 1876. He had fallen unconscious about twenty minutes before. Upon entering the ward he was in a state of unconsciousness, muttering delirium, profoundly relaxed, with a pungently hot, dry skin, rapid, feeble pulse, and greatly disturbed respiration. Death was apparently so imminent that no time was lost in making observations, but he was placed in a full bath of ice-water, with ice in great chunks piled over his exposed shoulders, neck, and head. After about five minutes his mouth temperature was 107°.5 F. From this time it steadily fell, and after some fifteen minutes it had reached 104° F., when very distinct signs of consciousness were developed, the man trying to get out of the bath. By the time his temperature had fallen to 102° F. he was entirely conscious, but the damage wrought was such that it was several days before he was perfectly clear in his statements. In this case the cause of the high temperature of the body was simply external heat. In the instance, detailed below, rheumatic irritation was the *materies morbi*.

This man was apparently doing fairly in a relapse of acute rheumatism, although his temperature had shown a distinct tendency to be very high. At 10:30 A. M. of the day in question he was seen by the Resident Physician of the Hospital, Dr. Bruen, who states: "When I saw him at 10:30 A. M. there was much less inflammation of the joints than on the preceding morning, and although his temperature was as it had been, 104° F., and, as I thought, a pericardial friction-sound could be heard, yet the man was doing fairly; perfectly rational, with a good pulse."

When I entered the ward about half-past twelve the patient was apparently dying. The pulse was between 160 and 170, exceedingly feeble and thready; the pupils strongly contracted, though not to pin-points; the respirations fifteen per minute, exceedingly irregular, mostly deep, jerking, and interrupted; the skin pale and dry; the consciousness completely lost, violent shaking and shouting in the ear only eliciting a few grunts; the temperature in the axilla 108°.8 F.; the wrists pale, and no signs of pain elicited by violently moving them. On ausculting the heart I could find no murmur; the first sound was very feeble, somewhat prolonged, and the second sharply accentuated.

Orders were immediately given to put the patient in a cold bath. The following is the record made at the time:—

1:24 P. M.—Patient put in a full bath at 60° F.

1:25½.—Shows signs of consciousness; will put out the tongue when loudly asked to do so.

1:27.—Seems to recognize that the bath is very cold, and struggles to get out.

1:30½.—Man has a fair degree of rationality. He has been in six minutes and a half, and is now ordered to be taken out at once.

One minute after the bath.—The patient was partially wiped and laid directly upon an india-rubber blanket, and covered only with a sheet, in a room whose temperature was about 65° to 70° F. He has just received a hypodermic injection of six grains of quinine.

Three minutes.—Temperature in axilla, 94° F.; in mouth, 105°.6 F.

Eight minutes.—Temperature has been steadily falling; is now 103° F. in mouth. The man has become perfectly rational, and answers to his name.

The further history of this case is omitted as not pertinent to the matter in hand, with the statement that recovery finally took place.[1]

This patient was not in the bath more than a minute and a half before he exhibited very distinct signs of returning consciousness, and in three minutes had sense enough to attempt to get out of the tub. What could the bath do to affect the man so much but withdraw the heat? That the heat was withdrawn, the thermometer proved. If the drowsiness had been due to simple congestion of the brain, very certainly would the bath, by driving the blood from the surface, have increased the trouble.

These cases might be abundantly paralleled and duplicated from medical records, but are sufficient to show that in man as well as in the lower animals the early withdrawal of the excess of heat is followed by subsidence of the symptoms. The result may be formulated in the following proposition:—

The withdrawal of the excess of heat in acute fever is followed by a relief of the nervous and circulatory disturbances.

Conclusions.—By the experiments and arguments set forth in this chapter, the following propositions have been proven:—

First. External heat applied to the body of normal animals, including man, so as to elevate the internal temperature, produces derangements of the functions of innervation, of respiration, of circulation, etc. etc. precisely similar to those seen in natural fever; the intensity of the disturbance being directly proportionate to the rise in temperature.

Second. Heat applied locally to the nerve centres and to the heart produces in the functions of these organs those disturbances which are familiar phenomena of fever, the intensity of the disturbances being directly proportionate to the excess of heat.

Third. The withdrawal of the excess of heat in acute fever is followed by a relief of the nervous and circulatory disturbances.

It would appear to follow as a direct corollary to these propositions that *excessive temperature* is the *essential symptom of fever.*

This seems to be true not only of severe, acute fever such as has been discussed here, but also of the lower grades of the febrile state. It must be borne in mind, however, that the course of the fever may modify or entirely suppress the symptoms which the increased temperature would normally produce. Thus it is conceivable that there should be a poison, which should at the same time increase tissue-change

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[1] A full report may be found in my Lecture on Fever. *Smithsonian Miscellaneous Collections*, No. 282, February, 1875; *ib.* vol. xv., 1878.

and depress the heart, and thereby lower the frequency of the cardiac beat, and reduce the force of the circulation although distinctly causing fever. It is notorious that in disease, fever coexists with almost every conceivable condition of the circulation, and indeed, if we can believe clinical records at all, may occur or continue after the cessation of circulation, *i. e.* in the post-mortem rise of temperature. This clinical fact abundantly confirms the conclusion reached in our propositions, and at the same time reveals the effect of modifying circumstances upon the typical phenomena of fever. Peculiarities of symptoms found in continued fevers, therefore, do not militate against the theory here inculcated. Every clinician who has employed the cold water treatment of typhoid and other fevers must have noted the subsidence of the nervous and circulatory disturbance under the use of cold; results which are the counterpart of those which occurred in the more acute cases heretofore reported in this paper. The elaborate researches of Zenker (*Ueber die Veränderungen der willkürlich. Musk. in Typhus Abdominalis*, Leipzig, 1864) have demonstrated the profound nutritive disturbances which occur in febrile diseases—apparently the direct result of continued heat of a mild type. These researches have been confirmed by the experiments of Dr. M. Litten (*Virchow's Archiv*, May, 1876). This observer found that, when guinea pigs are kept for some days in air heated steadily to from 96°.8 to 98°.6 F., fatty degeneration of most of the tissues is produced. The liver is usually affected first, the heart next, then the kidneys, the striated muscles, and finally the cellular tissue and to some extent the mucous membranes become involved.

It would appear therefore that after these many centuries we must acknowledge, as now demonstrated, the aphorism evolved from shadowy premises by the genius of Galen, *nam essentia quidem febrium est in caloris præternaturem* (*De Diff. Febr.*, Liv. i., chap. i.).

Having reached the conclusion just announced, two questions naturally offer themselves as requiring answer before it will be possible to determine the true nature and mechanism of the fever process.

First. What is the mechanism by which the production and dissipation of animal heat is regulated in the animal organism?

Second. Is the rise of temperature in fever due to the excessive retention or to the abnormal production of heat, or to both of these conjointly?

To the consideration of these questions the next two chapters of this memoir are devoted.

CHAPTER II.

CONCERNING THE METHODS BY WHICH THE ANIMAL ORGANISM CONTROLS THE PRODUCTION AND DISSIPATION OF HEAT.

In 1837, Sir Benj. Brodie (*Medico-Chirurg. Trans.*, 1837) observed the case of a man in whom, after a traumatic section of the spinal cord, the temperature rose in the course of a few hours to 111° F. Acting upon this hint, he made experiments upon animals, and found that in them, under certain circumstances, the temperature rose very greatly after division of the cord.

Studies of the effect of section of the cord upon the temperature have, since the time of Brodie, been made by very many observers, notably by Bernard (*Compt. Rend.*, 1852, 1853), Schiff (*Untersuchungen zur Physiologie des Nervensystems*, Frankfort, 1855), Chossat (*Meckel's Archiv*, 1852), Tscheschichin (*Reichert's Archiv*, 1866), Naunyn and Quincke (*Ibid.* 1869), Rosenthal (*Centralblatt*, April, 1869), Binz (*Virchow's Archiv*, 1870), Henri Parinaud (*Archiv. de Physiologie*, 1877). It is hardly necessary to trace, step by step, the various views which have been held by these authors, and I shall only speak of the results obtained by the more recent observers—results which I have myself experimentally determined to be correct.

If the cord of a rabbit or other small mammal be cut in the lower cervical region, the temperature, as measured in the victim, at once falls; and if the air of the apartment be decidedly below the warmth of the body this fall is permanent, and even progresses so that at death the animal heat is several degrees below the normal. If however the animal be thoroughly wrapped in raw cotton or in wool, and if the external temperature be not too low, the fall just spoken of is but temporary, and is succeeded by a rise of temperature which passes beyond the normal point, so that the animal dies in a state of fever. In my own experiments, the cooling of the body after death has often taken place more slowly than normal, but I have never seen that post-mortem rise of temperature which has been noted by Naunyn and Quincke, and by other observers, but which appears to be only an occasional phenomenon that is absent in the majority of cases. According to my own experience, (and the testimony of other investigators is in accord with it,) if the external temperature be much below that of the body of the animal, no amount of wrappings will suffice to bring about the febrile reaction; and if an animal in which the fever has already come on be exposed to external cold, the temperature falls. The time that elapses between the division of the cord and the rise of temperature varies from a few minutes to many hours, and is dependent upon the external conditions

If the animal be in a heated room, breathing heated air, the period of fall is a very short one. In none of my own trials, however, and in none of those reported by other observers, so far as I am aware, has the fall of temperature been altogether absent. In the experiments of Naunyn and Quincke, although the animal was put at once into a warm chest where the temperature was between 80° and 90° F., yet it was always several hours before the normal temperature was reached. The question here naturally arises, is the subsequent rise of temperature really due to the division of the cord, or is it due simply to the external heat to which the animal is exposed? An experiment apparently crucial as to this point was performed by Naunyn and Quincke. They first placed the uninjured animal in the warm box, and when after some hours no rise of its bodily temperature had occurred, divided the cord and replaced the animal in the warm chest, when intense fever came on in a very short time. Again these observers opened the spinal canal so as to completely expose the cord without cutting it, and placed the animal in the warm chest for the space of ten hours; at the end of this time the bodily heat had then risen six-tenths of a degree only. The following day the cord was divided and the animal replaced in the warm chest; in the first twenty minutes the bodily temperature fell nearly one degree, but rose three degrees in the next hour and twenty minutes, at the end of which time death occurred.

This comparatively rapid rise of temperature does not, however, always occur: thus in an experiment of Henri Parinaud (*op. cit.*, vi. p. 313), although the temperature of the uninjured animal finally rose higher than that of the injured, it at first rose more slowly. I have in a large number of cases seen the rise of temperature produced by exposure of an animal with cut cord to excessive heat (Experiments 41 to 46, in my paper on Nitrite of Amyl, *American Journal of the Medical Sciences*, July, 1871), but have performed only four experiments in which comparison was made.

Experiment 21.

A bitch.

Time.	Temp. of Chest.	Rectal Temp.	Remarks.
12:56 P. M.	83°.24 F.	102°.4 F.	
1:11	83.75		
1:26	82.76		
1:45	83.36		
1:56	83.53	104.9	Rise of temperature 2°.5 in hour; average temperature of chest, 83°.53.
2:20	.....	.....	Cord cut.
2:40	87.44	104.25	
2:55	87.55		
3:06	86.63		
3:25	86.18		
3:40	85.06	104	Fall of temperature 0°.25 in one hour; average temperature of chest, 86°.61.

Experiment 22.

A dog.

Time.	Temp. of Chest.	Rectal Temp.	Remarks.
12:51 P. M.	89°.33 F.	103°.1 F.	
1:05	93.6		
1:20	94.7		
1:35	94.7		

TIME.	TEMP. OF CHEST.	RECTAL TEMP.	REMARKS.
1:51 P. M.	98° F.	107°.6 F.	Rise 4°.5 in one hour; average temperature of hot chest, 94°.16.
2	.....	.....	Cord cut at first dorsal vertebra.
2:31	89.42	101.5	
2:46	90.68		
3:10	87.8		
3:16	89.3	104.9	Rise 3°.4 in ¾ hour—an hourly rate of 4°.6; average temperature of hot chest, 89°.3.

EXPERIMENT 23.

A dog.

TIME.	BOX TEMP.	RECTAL TEMP.	REMARKS.
12:33 P. M.	102°.1 F.	102°.65 F.	
1:48	99.7	105.44	Rise of rectal temperature, 2°.79; average box temp. 100°.9.
2:50	.....	.....	Cord cut in upper dorsal region.
3:35	102.1	97.25	
4:35	100.17	99.05	Rise of rectal temperature, 1°.8; average box temperature 101°.1.

EXPERIMENT 24.

A dog.

TIME.	BOX TEMP.	RECTAL TEMP.	REMARKS.
12:7 P. M.	99°.6 F.	103°.2 F.	
1:22	98.38	104.4	Rise of rectal temperature, 1°.2; average box temperature, 99°.
1:45	.....	.....	Cord cut in upper dorsal region.
1:52	99.3	103.1	
2:52	98.3	106	Rise of rectal temperature, 2°.9; average box temperature, 98°.8.

In looking over these experiments it will be seen that in the first the rise of the rectal temperature was nearly 2°.5 in an hour, before section of cord, but that after the operation the rectal temperature fell 0°.25, although the surrounding air was 3° warmer after than before the division of the cord. In the second experiment the rectal temperature rose practically at the same rate after and before division of the cord, although the surrounding temperature was over 5° lower after than before the section. In the third experiment in atmospheres of equal heat, before section the rectal temperature rose about one-half more than it did after section; whilst in the last trial the rise was double after section, although the surrounding temperature was less.

These experiments, taken in conjunction with those of Binz, Naunyn and Quincke, Parinaud, etc., lead to the conclusion that usually the animal heat rises faster in a hot atmosphere after than before section of the cord, but that in some cases the reverse occurs. According to my experience the stronger the animal the more probability there is of an excessive rise after division of the spinal cord.

Various theories have been propounded to account for the changes of temperature which follow section of the spinal cord. Any one of these theories may or may not be correct, all of them resting upon merely deductive reasoning, and no one of them having been demonstrated. Indeed up to the present moment, the primary question—Is the first fall of temperature due to a lessened production, or to an abnormal throwing off, of bodily heat?—really remains unanswered. It is to solve this problem that the next series of experiments, recorded in this chapter, were attempted.

According to Lavoisier (*Elements of Chemistry*, Robt. Kerr's Translation, p. 343, Edinburgh, 1790) the first person to make an instrument to measure heat given

off from a body was M. de la Place. The first to apply the calorimeter to the measuring of animal heat was M. Dulong, who detailed the account of his experiments to the French Academy in 1822, but did not publish it in full until 1841 (*Annales de chimie et de physique*, 3me série, tome i. p. 440). In June, 1823, M. Despertz obtained a prize from the French Academy for his paper upon the Causes of Animal Heat (*Annales de chimie et de physique*, tome xxvi. p. 337). In 1872 Dr. Senator (*Archiv für Anatomie, Physiologie und Wissensch. Medecin*, p. 1) gave to the world a very important paper, entitled Untersuchungen über die Wärmebildung, in which he described a calorimeter differing from that previously employed, in that the outer case was surrounded by a non-conducting medium. I shall not enter into a detailed description of any of these instruments, as elaborate historical matter is foreign to the intention of the present paper. It does, however, seem proper to state that the apparatus used by myself is similar in the general principles of its construction to that employed by Senator.

As some difficulty was met in making an apparatus which should stand the test of continuous work, and as the value of the present memoir is dependent upon the accuracy of the apparatus employed, a detailed account of it as finally perfected is offered.

The essential portion of the apparatus consists of a double metallic box, which is placed in some non-conducting substance contained in a wooden case or box. For the metal work the so-called "galvanized sheet-iron" was selected. It has stood the test of three years' intermittent work without rusting, and is much less expensive than copper.

The inner box, which rests on feet, (Pl. II. fig. 1, A) has in the end a movable circular lid (fig. 2, a) or door formed of heavy galvanized iron. Around the edge of the opening upon which this door fits is a series of screw posts (fig. 2, B), and in the lid are holes corresponding with these posts; just inside the line of these orifices is soldered a heavy wire. A piece of thick, soft rubber is also so shaped and perforated as to cover the box opening and to allow the posts to come through. When the outer iron covering and this piece of rubber are in position, thumb-screw nuts are tightly screwed down, so that the inner rim of the lid nips the india-rubber and makes a thoroughly water-tight joint.

The inner box (fig. 1, a) has running up from it at each end, a vertical pipe (B), tipped with a brass flange joint, of such length that, when the apparatus is in working position, it just reaches through the lid of the outer box, so that when a nozzle is screwed firmly down upon a leather washer a water-tight joint is formed. One of these pipes reaches nearly to the bottom of the inner box, the other opens at the top. In this way air forced in through one and out through the other has to circulate through the box. It is necessary to protect by heavy semicircular wires the long tube so that the animal cannot disturb it.

The outer box, also of galvanized iron, has a movable lid over its whole top. Some difficulty was experienced in getting a joint which, whilst allowing the lid to be easily shifted, should be both durable and tight. The following device was found to answer perfectly: The iron of the upright sides and ends of the outer box is so bent at right angles, first outwards and then upwards, as to offer a flat

horizontal surface of an inch in width, with an outer upright flange of at least an inch and a half in height. In order to make all tight, solder must be freely used at the corners of the box. In the space thus formed is cemented, by means of soft rubber dissolved in benzine, a thick piece of unvulcanized india-rubber. Upon the inner edge of the lid (fig. 3) is soldered a heavy wire (fig. 3, a). When the lid is placed in position, a strip of hard wood is laid over each edge and three or more clamps (fig. 1, x) are tightly screwed down upon it. The wire of course buries itself in the soft rubber, and a perfectly tight joint is obtained.

The lid has in it five holes, two of these (fig. 3, c) receive the tubes from the inner box; through a third (x) the stirrer projects, and the remainder (y) are fitted with milled screw-caps so that they can be opened or closed at will. These are for taking the temperature of the water as well as for the purpose of filling and emptying the box; they must be so placed that they are exactly over the space between the inner and the outer box, in order to allow the thermometer to descend readily.

When water is put into the large box the inner box floats upward with great force; to obviate this a pair of projecting pieces of iron (fig. 1, x) are riveted upon the inside of the larger box in such a way that when a bar is slipped under them it will hold the smaller box down in position. The stirrer consists of a broad piece of iron the length of the width of the inner box, with an iron rod fastened at right angles to it; the flat part when the apparatus is in working condition lies upon the bottom, and as it can be drawn up and down by the iron rod, it affords an efficient means of producing agitation in the water.

When the apparatus (fig. 1) is arranged for use, the animal is placed in the inner box, and between the boxes is a layer of water (w), and surrounding the whole is sawdust, cow's hair, or other non-conductor (s). One of the tubes from the inner box communicates directly with the open air, the other with a pump which draws a current of air through the box and through a gas meter. The air drawn from the box passes around and about a thermometer bulb, so that its temperature is readily taken. If the temperature of the air as it enters and as it leaves the box be known, and also its quantity, and if, likewise, the quantity of the water and the weight of the iron containing it, and also their temperature when the animal is put in and when it is taken out be ascertained, it is a very simple matter to calculate the amount of heat given off by the animal.

The calorimeter, as described thus far, makes no provision for estimating the heat lost or gained by vaporization or condensation of moisture within the chamber. In some European instruments this difficulty is avoided by leading the exit tube at some length around through the water which is kept at a low temperature so as to condense all the vapor. The objections to this arrangement are to my thinking apparent. In the first place, heat may be obtained by condensation of vapor coming in with the external air, especially as the water should be cooler than the air, for reasons to be mentioned directly; in the second place, the completeness of the condensation is always uncertain. A more accurate plan is found in the analysis, for moisture, of a measured sample of the air leaving the box, and also of that entering the box, by means of sulphuric acid bulbs or chloride of calcium tubes.

In some of our experiments the samples drawn off from the main currents of air

were examined not only for moisture but also for carbonic acid gas, so that the elimination of carbonic acid was studied along with the development of animal heat.

There is, of course, loss of heat from the most perfect calorimeter. At first sight this may appear of no importance in relative experiments. Experience, however, has shown that the instrument, unless used with great care, yields the most fallacious results. In testing the apparatus, of the two non-conducting packing materials employed, fine, perfectly dry sawdust seemed to yield the best results. But even with it, especially when the water was much above the temperature of the air, the loss of heat was more or less irregular, unless great care was employed. The first precaution to be taken is to have the apparatus itself of a uniform temperature throughout; so that water, iron, and sawdust should all be one in this respect. Over-warming the apparatus previous to use, or using it when it is decidedly below the temperature of the water, is equally fatal to accuracy.

The amount of loss from the calorimeter is of course directly dependent upon the relation between its temperature and that of the external air; the greater the difference the greater the loss.

The question very early arose as to whether the temperature of the water should approximate that of the air or that of the animal. A trial soon showed that when the water was near the temperature of the animal, the loss of heat from the calorimeter was not only enormous but also very irregular on account of the difficulty of heating the apparatus uniformly through to such a temperature. Again, an animal taken out of an ordinary room and thrust into a confined chamber heated to 100° F. or thereabouts, suffers violence in its environment, and is put under such unnatural conditions as to vitiate more or less the result. The correct use of the calorimeter evidently depends upon the keeping of its temperature equable, and as near as may be to that of the external air. It should always, in winter, be used in a room heated steadily to 70° F.

In order to show in a measure the loss of heat from the apparatus, the following series of trials were made with the two calorimeters with which nearly all the work of the paper was performed. In these trials the temperature of the water was a little above that of the external air, and the air was drawn through the inner box at a steady rate.

Trial No. 1.—*Largest Calorimeter.*

Time.	Box Temp.	Air Temp.	Hourly Loss of Box Temp.	Average Diff. bet. Air and Box.
2:30 P. M.	76.°91 F.	71°.96 F.		
2:45		71.33		
3		71.33		
3:15		72.42		
3:30	76.52	72.72	"0°.39 F.	5°.76 F.

Trial No. 2.—*Largest Calorimeter.*

Time.	Box Temp.	Air Temp.	Hourly Loss of Box Temp.	Average Diff. bet. Air and Box.
10:53 A. M.	74°.3 F.	65°.12 F.		
11:10		64.22		
11:25		64.31		
11:40		64.31		
11:53	74	64.58	0°.3 F.[1]	9°.7 F.

[1] The apparatus had been running several hours before at a very high temperature, 100°, and though effort was made to get it uniformly cooled, the amount of loss may have been affected.

Time.	Box Temp.	Air Temp.	Hourly Loss of Box Temp.	Average Diff. bet. Air and Box.
12:08 P. M.	74°.2 F.	64°.58 F.		
12:23		64.67		
12:38		64.67		
12:55		64.88		
1:08		65.12		
1:23		64.80		
1:38	73.79		0°.23 F.[1]	9°.1 F.
1:48	70.34	65.90		
2:05		65.66		
2:20		65.96		
2:35		65.96		
2:48	70.16	66.68	0.18	4.2
3:05		66.68		
3:20		66.56		
3:35		66.56		
3:48	69.98	66.68	0.18	3.4

Trial No. 3.—*Largest Calorimeter.*

Time.	Box Temp.	Air Temp.	Hourly Loss of Box Temp.	Average Diff. bet. Air and Box.
10:33 A. M.	62°.96 F.	59°.5 F.		
10:48		58.9		
11:03		58.9		
11:18		59.5		
11:33	62.72	59.7	0°.24 F.	3°.84 F.
11:48		58.9		
12:03 P. M.		60.1		
12:18		60.4		
12:32		60.5		
12:48		60.7		
1:03		60.8		
1:18	62.32	61.4	0.23	2.52
1:33		61.1		
1:48		61.1		
2:03		60.4		
2:18	62.20	60.5	0.12	1.42
2:33		61.3		
2:48		61.3		
3:03		61.5		
3:18		61.6		
3:33	62.01	61.7	0.08	0 60
3:48		61.6		
4:03		61.6		
4:18		61.6		
4:33	62.00	61.5	0.09	0.60

Trial No. 4.—*Largest Calorimeter.*

Time.	Box Temp.	Air Temp.	Hourly Loss of Box Temp.	Average Diff. bet. Air and Box.
11:39 A. M.	70°.79 F.	65°.48 F.		
11:54		65.40		
12:09 P. M.		65.48		
12:24		65.48		
12:39		65.90		
12:54				
1:09	70.43	66.68	0°.24 F.	4°.9 F.
1:25		67.76		
1:40		68.00		
1:55		67.54		
2:09	70.25	68.36	0.18	2.75
2:20		68.63		
2:35		68.63		
2:45		69.62		
3:09	70.11	70.52	0.14	1.00

[1] The apparatus had been running several hours before at a very high temperature, 100°, and though effort was made to get it uniformly cooled, the amount of loss may have been affected.

Trial No. 1.—*Small Calorimeter.*

Time.	Box Temp.	Air Temp.	Hourly Loss of Box Temp.	Average Diff. bet. Air and Box.
11:56 A. M.	82°.04 F.	74°.57 F.		
12:15 P. M.		74.66		
12:30		74.48		
12:45		75.29		
12:56	81.41	75.38	0°.63 F.	6°.85 F.
1:15		75.08		
1:30		75.38		
1:45		75.80		
1:56	80.63	76.37	0.78	5.40
2:15		76.46		
2:30		76.28		
2:45		76.19		
2:56	80.14	76.19	0.49	4.10
3:15		75.56		
3:30		75.80		
3:45		75.47		
3:56	79.70	75.47	0.44	4.20

Trial No. 2.—*Small Calorimeter.*

Time.	Box Temp.	Air Temp.	Hourly Loss of Box Temp.	Average diff. bet. Air and Box.
1:32 P. M.	82°.22 F.	72°.68 F.		
1:47		72.41		
2:02		72.32		
2:17		72.77		
2:32		73.66		
2:47		72.95		
3:02	81.22	73.04	0°.67 F.	8°.90 F.
3:17		73.55		
3:32		73.55		
3:47		74.30		
4:02	80.60	74.39	0.62	7.14
4:17		73.76		
4:32		74.48		
4:47		74.12		
5:02	80.12	74.21	0.48	6.17

Extended comment upon these tables does not seem necessary. They appear to show conclusively that the nearer the apparatus is in temperature to the air the less the chance of serious error; also that in comparative experiments, when the calorimeter is above the temperature of the air, the least chance of serious error is to be obtained by maintaining the conditions uniform during the whole experiment, rather than by attempting to calculate the amount of heat lost by the calorimeter under varying conditions. Besides the trials reported, a number of others were performed in which the calorimeter was *below* the temperature of the air. These conclusively proved what is, *à priori*, probable, that, when the difference of temperature is not more than three degrees, the calorimeter works with almost exact accuracy; there is of course no loss of heat from the calorimeter, and its power of absorbing caloric from the air seems to be nill. Unfortunately I did not appreciate the importance of having the calorimeter cooler than the air until late in the investigation, but relied for accuracy upon maintaining similar conditions throughout each single experiment, and keeping the difference between the temperatures of the air and calorimeter as little as possible. The chief safeguard against error has seemed to me to be found in having a number of experiments. If in such a series of similar relative experiments upon animals the result is at the same time fairly uniform and very decided in one direction, it is practically demonstrated that the

errors of the instrument are decidedly less than the margin of increase or decrease of the heat lost.

The complete apparatus[1] which I have employed consists of two parts: 1st, the apparatus for analyzing the air of the room; 2d, the calorimetrical apparatus proper. The first of these is composed of an aspirator, meter, barium tubes, and sulphuric acid bulbs, or chloride of calcium tubes. The second (Pl. I.) consists of the calorimeter proper (a) already described, sulphuric acid bulbs (b), tubing, two meters, and a large and small air pump. When it is arranged and working, the air, whose temperature is measured by a thermometer hanging near by, enters the calorimeter at x, and emerges at y; immediately after this the current is tapped by means of a side pipe (z) whose end projects as a sort of nipple into the centre of the lower of the larger tubes. Directly afterwards the main current passes over the bulb of the thermometer (t), by the scale of which its temperature may be read. It then passes on to the large or "air meter" (m) and out through the air pump (p). The sample, immediately after being drawn out at z, passes through the sulphuric acid bulbs and is robbed of its water; travelling onward it loses its carbonic acid in the tubes (b b) which contain a solution of caustic barium. Finally, having registered its quantity in the small or "sample meter" (m′), it is drawn into the aspirating bottles (v v). It is plain that the sum of the amounts registered in the large and small meters is the quantity of the air which has in any given time passed through the box. There are one or two details in the running of the apparatus, not yet mentioned, worthy of specific notice. It is necessary to take especial precautions that no moisture is deposited in the tubing before the bulbs (s) are reached; hence the bulbs should be placed as near as possible to the orifice (y), and the tubes should be made exclusively of wood and rubber. In order to render the thermometer-joint tight, melted paraffine should be poured into it.

Before detailing the calorimetrical experiments, it is perhaps best to give an explanation of the methods of recording and of calculation. This can be done most clearly and briefly by presenting as an example the report of a portion of an actual experiment.[2]

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rectal Temp. (Fah.)	Gen. Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium tube. (grms.)	Air Cal. tube. (grms.)
1:59 P.M.	64°.3	67°.3	67°.2	102°.9	169.88	98.725	17.1079	11.0000	10.010
2:14	64 9	66.6							
2:29	65.1								
2:44	66.2	66.6							
3:14	67.	67.8							
3:29	66.2	67.4	67.6	100.76	253.12	98.9601	17.4142	11.1184	10.0679
	65.62 (mean)	67.14	0.4 (gain)	2.14 (loss)	83.24	0.2351	0.3063	0.1184 (gain)	0.0579 (gain)
		65.62			0.2351				
		1.52			83.4751				

[1] It is allowable to state that great pains had been taken to insure accuracy in the apparatus. The meters were "Godwin's Experimental Meters," tested with the greatest care. The thermometers were all laboriously compared with the normal one in the physical laboratory of the University; tables were formed of their variations, and the recorded temperatures are corrected temperatures.

[2] In this memoir, unless otherwise distinctly stated, the temperatures are according to the Fahrenheit scale; the air measures (general, sample, and air meters) in cubic feet; and the calcium tubes (also CO_2 when mentioned) in grammes.

In examining this table it will be seen that the first four narrow columns, after the time record, are taken up with registers of temperature: the first of these represents the temperature of the air as it enters the box; the second that of the air as it leaves the box, both taken every fifteen minutes. The figures at the bottom of these two columns represent the respective averages, and it is plain that if the smaller number be subtracted from the larger the average gain or loss of heat by the air during its passage will be ascertained. Thus in the table given, the second column, that of exit, gives an average of 67°.14; whilst the first column, that of entrance, gives an average of 65°.62, showing that the air gained an average of 1°.52 during its passage. If, however, the average of the first column had been 67°.14, and that of the second 65°.62, it would have shown that the air had cooled 1°.52 during its passage. It is plain that the gain or loss of heat by the air in flowing through the box must be respectively added to or subtracted from the heat given to the calorimeter by the animal in order to determine the dissipation of heat by the latter. To do this it is necessary that the calculation be made in heat units. I have adopted the English unit of heat, namely, the amount of heat required to raise one pound of water one degree Fahrenheit, because the scales of the various instruments employed conform most readily with this standard.

The amount of heat employed in elevating the temperature of any body is calculated by the well-known formula $Q = W \times t \times$ sp. h., in which Q is the quantity of heat employed, W the weight of the body, t the temperature which it is raised, and sp. h. the specific heat of the body. In applying this formula to the air in the experiments a difficulty presented itself. The quantity of the air which has passed through the box and been cooled or heated is easily known. The first broad column of the table gives the readings of the general meter before and after the experiment; subtracting the first number from the second gives the amount of air which has passed through the large general meter; add to this the amount which has passed through the sample meter (registered in second broad column), and the whole quantity of air which has been drawn through the box is known. The weight of a cubic foot of air at 32° F. is 0.08073 lb. The air in the box is of various temperatures in different experiments, and is always much expanded by the heat; hence it is necessary to reduce by calculation the volume of the air to what it would be if the box were cooled to 32° F. In doing this I have considered the temperature of the air of the box as that at which it emerges. This is not strictly correct, but the error is so small as to be of no possible importance. Taking then this temperature, and using the following letters to signify as given below, the calculation becomes a simple one. V = quantity of air in cubic feet at 32°. V′ = known quantity of air at a known temperature. t′ = number of degrees this quantity is heated above 32°. Then $V + [V \times t' \times 0.002035$ (coefficient of expansion)$] = V'$. Using as a type the experiment recorded above, we have

$$V' = 83.475. \quad t' = 67°.14 - 32° = 35.14. \quad V + (V \times 35.14 \times 0.002035) = 83.475.$$

$$V + 0.0715\ V = 83.475. \quad V = \frac{83.475}{1.0715} = 77.9 \text{ cub. ft.}$$

The quantity of air at 32° being known, the weight is readily ascertained:

$$W = V \times 0.08073 \text{ (weight of 1 cubic foot at 32° F.)} = 6.289 \text{ lbs.}$$

The elevation of the temperature of the air during its passage, in the experiment under discussion, is $t = 1°.52$ in the formula, $Q = W \times t \times$ sp. h. The specific heat of air is 0.2374, and the formula becomes

$$Q = 6.289 \times 1.52 \times 0.2374 = 2.2694.$$

The heat given to the air by the animal is therefore 2.2694 units.[1]

The animal in the box is constantly giving off moisture, and heat is becoming in this way insensible; condensation of moisture also may or may not be going on in the box. In order to estimate the disturbance of heat in this way, as already explained, calcium tubes or sulphuric acid bulbs were employed. The gain of weight of the sample in calcium tubes, as shown in its appropriate column, is 0.1184 gramme. In order to determine how much moisture is in the air coming from the box, the amount of the sample (0.2351) is divided into the whole amount of air passed through the box, and the moisture in the sample is multiplied by the resultant, which represents the proportion between air and sample, and is known in this measure as the *quotient for the box.* Thus $\frac{83.4751}{0.2351} = 355 =$ quotient for the box. Thus 0.1184 gramme $\times$ 355 = 42.032 = whole amount of moisture coming from the box. By a similar process the amount of moisture entering the box is calculated. The "*quotient for air*" is obtained by dividing the whole amount of air passed through the box by the amount of the air analyzed in the outside apparatus. Then this is multiplied by the amount of moisture found in the analyzed air. Thus $\frac{83.4751}{0.3063} = 272.5 =$ quotient for air. $272.5 \times 0.0579 = 15.778 =$ moisture entering the box.

Moisture leaving box,	42.032 grammes.
Moisture entering box,	15.778 grammes.
Moisture evaporated in box,	26.254 grammes.

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[1] Strict accuracy would of course require that allowance be made for barometrical variations, and that the pressure be reduced to the standard pressure 29.92 inches. This has not been done in any of my experiments, because the resultant error is so small as to be of no importance whatever. The experiments were mostly performed in the course of a few successive hours, and changes in the barometer in such a period rarely amount to $0^{in}.5$. Assuming 30 inches as the standard, and that in the present instance the barometrical pressure was $30^{in}.5$, the calculation would be

$$V' = \frac{V''\rho''}{\rho'} = \frac{83.475 \times 30.5}{30} = 84.87. \qquad V' = \frac{84.87}{1.0715} = 79.2. \qquad W = V' \times 0.08073 = 6.394.$$

$$Q = 6.394 \times 1.52 \times 0.2374 = 2.3072.$$

It will be seen that the difference between this result and that arrived at is only 0.0378. When it is borne in mind that the supposed barometrical variation is extreme, that the experiments are all relative, and that in final comparisons of results no decimals are of any importance, it is plain that no injury is done by the omission of barometrical allowances. Even in the fever experiments, allowing for a possible barometrical variation of one inch, only the second decimal would be affected and that to a very slight extent. It must be borne in mind that absolute accuracy cannot be reached in any of these measurements of heat production, and that the truth of a fact can only be established by the variations of heat production being so large and so constant as to remove the danger of error. Errors must sometimes preponderate in one direction, sometimes in another, and if results are always the same, the error must be unimportant.

This is then divided by 497.603 to reduce it to pounds, and becomes 0.05276 lb. A pound of water requires 79.25 heat units to vaporize it; and $0.05276 \times 79.25 = 4.181 =$ units of heat expended in process of vaporization in the box. The same result will of course be obtained by dividing the 26.255 by 6.2789, since $\frac{497.603}{79.25} = 6.2789$.

In the fourth column of the tabulated report of the experiment, is given the temperature of the water in the box at the commencement and at the end of the time during which the animal was in the calorimeter; the difference, which is stated at the bottom of the column, of course represents the gain of temperature by the water, and in the present instance is 0.4. It is evident that the metal of the calorimeter shares with the water in this increase of temperature, and that this heat must be estimated. The most convenient form is to calculate first the thermal equivalent of the calorimeter as the basis of experimentation. Thus, in the largest instrument employed in my experiments, there were 157 pounds of water and 60 pounds of iron. The specific heat of water at the temperature of 60° is very nearly 1.002, of iron 0.11379, suppose $t = 1$.

$Q = w \times t \times$ sp. h. $= 157 \times 1 \times 1.002 =$	157.314
$Q = w \times t \times$ sp. h. $= 60 \times 1 \times 0.11379 =$	6.8274
The amount of heat required to raise calorimeter 1° F.	164.1414 units.

In the experiment under consideration it is plain that $164.1414 \times 0.4 = 65.6565$ units = the amount of heat imparted to the calorimeter.

Finally the calculation is summarized as follows:—

Heat given to air	2.2694
Heat expended in vaporization	4.181
Heat given to calorimeter	65.6565
Total gain of heat in $1\frac{1}{2}$ hours, in excess of that lost by the apparatus	72.1069
Hourly gain of heat, in excess of that lost by the apparatus, expressed in English units	48.0713

In many of the experiments an attempt was made not only to measure the amount of heat given off, but also the production of carbon dioxide. The sample of air taken from the box current was analyzed, and the amount of carbon dioxide contained in it on being multiplied by the quotient for the box gave the total amount (a) of carbon dioxide coming from the box. Then the amount of gas contained in the sample of air analyzed multiplied by the quotient for the air gave the quantity of the dioxide which entered the box (b). Subtracting these results, b from a, the total elimination of carbonic acid by the animal became known.

One of the most common methods employed in the determination of carbon dioxide (CO_2) consists in conducting the evolved gas into a solution of calcium hydrate, and after allowing sufficient time for the amorphous calcium carbonates to become crystalline, filtering it. After washing it is decomposed with an acid, and the

liberated CO_2 caught in weighed soda-lime tubes, or Liebig's bulbs, and the amount of CO_2 ascertained by the difference in weight.

The method of Pettenkofer for the absorption and estimation of gaseous carbon dioxide is far superior to the above procedure, and was, therefore, the one adopted in the investigation.

It is as follows: Normal solutions of barium hydrate and oxalic acid are first prepared. The solution of the latter is so arranged that one litre will contain 2.8636 grms. crystallized oxalic acid. The latter should not show any signs of weathering or be moist; should be dried several hours over H_2SO_4 before use. The water employed in the experiments is freed from carbon dioxide by boiling. The concentration of the barium hydrate is so arranged that 1 cub. cm. of it will correspond to 3 cub. cms. of oxalic acid; but, when only small quantities of CO_2 are to be absorbed, the concentration of both liquids is about the same, *i. e.*, 1 cub. cm. of $Ba(HO)_2$ = 1 cub. cm. of $C_2H_2O_4$.

After having prepared these solutions of known strength, and by experiment satisfied yourself as to the relation they bear to each other, introduce a measured volume of $Ba(HO)_2$ into one or more long glass tubes, which are placed in an inclined position, and permit the carbon dioxide to stream through the liquid. When the absorption is complete, and the experiment finished, the liquid $Ba(HO)_2$ is titrated and the quantity of CO_2 ascertained from the difference in the first and second titrations.

In the first series of experiments of this chapter the amount of heat dissipated and carbon dioxide produced hourly having been obtained in the uninjured animal, the spinal cord was divided and the dog replaced in the apparatus. On his removal the hourly dissipation of heat and production of carbonic acid were determined, and it became a very simple matter to estimate the change of heat dissipation and of carbonic acid production which followed the section of the cord.

The experiments are as follows: In some of them the heat lost in vaporization was not noted, but the variation in the vaporization before and after section was so slight in the experiments in which it was noted, that the omission does not at all invalidate the results.

Experiment 25.

A dog; weight 18 pounds.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks. (grms.)
1:59 P.M.	64°.3	67°.3	67°.2	102°.9	169.88	98.725	17.1079			
2:14	64.9	66.6								
2:29	65.1									
2:44	66.2	66.6								
3:14	67.	67.8								
3:29	66.2	67.4	67.6	100.76	253.12	98.9601	17.4142			CO_2 in sample 0.0357
										CO_2 in air 0.007125
	65.62	67.14	0.4	2.14	83.24	0.2351	0.3063	0.1184	0.0579	
	(mean)	65.62	(gain)	(loss)	0.2351			(gain)	(gain)	
		1.52			83.4751					
		(gain)								

4 P. M.—Cord cut at 5th cervical vertebra; very little bleeding; complete paraplegia.
4:15 P. M.—Rectal temperature, 101°.5.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks. (grms.)
4:45 P.M.	65°.3	67°.9	68°.05		277.23	98.9601	17.4142			
5	65.4	68.0								
5:15	65.2	67.8								
5:30	65.2	68.0								
5:45	65.7	68.1								
6	66.1	68.2								CO_2 in sample 0.018
6:15	66.7	68.2	68.9	89	358.34	99.0573	17.5905			CO_2 in air 0.0065
	65.66 (mean)	68.03 65.66 (gain)	0.85 (gain)		81.110 0.0972	0.0972	0.1763	0.0651 (gain)	0.0409 (gain)	
		2.37 (gain)			81.2072					

Before Section.

Quantity of air (V′) = 83.4751 at 67°.14—32° = 35.14 = t′. $V + (V \times t' \times 0.002035) = V'$.

$V = \frac{83.4751}{1.0715} = 77.9$. $W = V \times 0.08073 = 6.289$.

Rise in temp. of air 1.52 = t. $Q = W \times t \times$ sp. h. $= 6.289 \times 1.52 \times 0.2374 = 2.2694$ = heat given to air.

Quotient for box $\frac{83.4751}{0.2351} = 355 \times 0.1184 = 42.032$ = moisture leaving box.

Quotient for air $\frac{83.4751}{0.3063} = 272.5 \times 0.0579 = 15.778$ = moisture entering box.

26.254 = moisture vaporized in box.

$\frac{26.254}{6.2789} = 4.181$ = heat expended in vaporization.

Rise in temp. of water $0.4 \times 164.1414 = 65.6565$ = heat given to calorimeter.

2.2694 = heat given to air.

4.181 = heat expended in vaporization.

72.1069 = heat dissipated in 1½ hours.

Hourly dissipation of heat 48.0713

After Section.

Quantity of air (V′) = 81.2072 at 68°.03—32° = 36.03 = t′. $V + (V \times t' \times 0.002035) = V'$.

$V = \frac{81.2072}{1.073} = 75.6$. $W = V \times 0.08073 = 6.1$.

Rise in temp. of air 2.37 = t. $Q = W \times t \times$ sp. h. $= 6.1 \times 2.37 \times 0.2374 = 3.4321$ = heat given to air.

Quotient for box $\frac{81.2072}{0.0972} = 835.4 \times 0.0651 = 54.3845$ = moisture leaving box.

Quotient for air $\frac{81.2072}{0.1763} = 460.6 \times 0.0409 = 18.8385$ = moisture entering box.

35.546 = moisture vaporized in box.

$\frac{35.546}{6.2789} = 5.661$ = heat expended in vaporization.

Rise in temp. of water $0.85 \times 164.1414 = 139.5202$ = heat given to calorimeter.

3.4321 = heat given to air.

5.661 = heat expended in vaporization.

148.6133 = heat dissipated in 1½ hours.

Hourly dissipation of heat 99.0755

Summary.

Hourly dissipation of heat after section	99.0755
Hourly dissipation of heat before section	48.0713
Gain in hourly dissipation of heat following section	51.0042

Carbonic Acid.

BEFORE SECTION.

0.0357 × 355 = 12.6735 grammes CO_2 leaving box.
0.007125 × 272.5 = 1.9415 grammes CO_2 entering box.

Production of carbonic acid in 1½ hours 10.732 grammes.
Hourly production of carbonic acid 7.1547 grammes.

AFTER SECTION.

0.018 × 835.4 = 15.0372 grammes CO_2 leaving box.
0.0065 × 460.6 = 2.9939 grammes CO_2 entering box.

Production of carbonic acid in 1½ hours 12.0433 grammes.
Hourly production of carbonic acid 8.0288 grammes.

SUMMARY.

Hourly production of carbonic acid after section 8.0288 grammes.
Hourly production of carbonic acid before section 7.1547 grammes.

Increase of hourly production of carbonic acid following section 0.8741 grammes.

EXPERIMENT 26.

A large terrier; weight 25 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)
12:12 P. M.	81°.6	80°.96	76°.7	102°.4	610.51	77.0512
12:27	82.4	81.3				
12:42	81.6	81.4				
12:57	83.2	81.9				
1:15	82	81.9				
1:30	82.3	82.2				
1:45	83.3	83.6				
2	83.6	84.4				
2:12	84.5	84.2	79.2	103.46	777.04	77.3917
	82.72	82.43	2.5	1.06	166.53	0.3405
	82.43	(mean)	(gain)	(gain)	0.3405	
	0.29 (loss)				166.8705	

Cord cut between second and third dorsal vertebræ at 2:41 P. M.; rectal temperature 103°.46.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)
3:20 P. M	85°.7	86°	75°.8	864.25	77.391
3:35	85.4	85.5			
3:50	85.2	85.			
4:5	85.9	86.4			
4:20	85.5	85.5			
4:35	85.3	85.			
4:50	85.3	84.4			
5:5	85.	83.9			
5:20	84.8	84.5	79.4	1031.04	77.7088
	85.34	85.13	3.6	166.79	0.3178
	85.13	(mean)	(gain)	0.3178	
	0.21 (loss)			167.1078	

BEFORE SECTION.

Quantity of air (V′) = 166.8705 at 82°.43 — 32° = 50.43 = t′. $V + (V \times t' \times 0.002035) = V'$

$V = \frac{V'}{1.1} = 151.7$. $W = V \times 0.08073 = 12.24$. Fall in temp. of air 0.29 = t.

$Q = W \times t \times$ sp. h. $= 12.24 \times 0.29 \times 0.2374 = 0.8427$ = heat taken from air.

Rise in temp. of water 2.5. $164.1414 \times 2.5 = 410.3535$ = heat given to calorimeter.

0.8427 = heat taken from air.

409.5108 = heat dissipated in two hours.

Hourly dissipation of heat 204.7554

AFTER SECTION.

Quantity of air (V′) = 167.1078 at 85°.13 — 32° = 53.13 = t′. $V + (V \times t' \times 0.002035) = V'$.

$V = \frac{167.1078}{1.108} = 150.8$. $W = V \times 0.08073 = 12.17$. Fall in temp. of air 0.21 = t.

$Q = W \times t \times$ sp. h. $= 12.17 \times 0.21 \times 0.2374 = 0.6067$ = heat taken from air.

Rise in temp. of water 3.6 × 164.1414 = 590.909 = heat given to calorimeter.

0.6067 = heat taken from air.

590.3023 = heat dissipated in two hours.

Hourly dissipation of heat 295.1511

SUMMARY.

Hourly dissipation of heat after section	295.1511
Hourly dissipation of heat before section	204.7554
Hourly increase of heat dissipation following section	90.3957

Carbonic Acid.—In this experiment the apparatus for the analysis of the air broke down, and consequently no account was obtained of the amount of carbonic acid entering the box. *Before section*, however, the whole amount of carbonic acid, which was contained in the air leaving the box, was 2.457954 grammes; whilst, after section, the air yielded 4.41007 grammes of the acid. It is evident, therefore, that there was a decided increase in the elimination of the gas following section, although it is not possible to state exactly the amount of such increase.

EXPERIMENT 27.

A long-haired cur; weight 32 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE. TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS (grms.)
12:52 P. M.	68°.9	68°.8	67°.3	102°.5	413.311	0.0	28.6			
1:17	68.1	68.9								
1:22	68.4	68.8								
1:37	68.1	68 5								
1:52	68.6	69.2								
2:7	69.4	69.4								CO_2 in sample 0.016125.
2:22	69.5	70	68.45	102.5	488.03	0.0937	28.7067			CO_2 in air 0.0055.
	68.71	69.08	1.15	0.0	74.719	0.0937	0.1067	0.0509	0.0236	
(mean)	68.71	(gain)			0.0937			(gain)	(gain)	
	0.37 (gain)				74.8127					

2:40 P. M.—Cord cut at 5th cervical vertebra. The breathing instantly became very labored: at 3:4 P. M. the animal was intensely cyanotic, the lips and mouth blue. Rectal temp. 102°.5.

Time.	Air Temp. (Fah.)	Tube. Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks. (grms.)
3:19 P.M.	71°.8	71°.1	67°.5		506.07	0.0937	28.7067			
3:34	70.9	71.2								
3:49	70.8	71.1								
4:4	71.3	71.1								
4:19										
4:34	72.1	72.1								CO_2 in sample 0.0155.
4:49	72.9	72.9	69.2	97°.16	579.65	0.1689	28.9022			CO_2 in air 0.0075.
	71.63	71.58	1.7		73.58	0.0752	0.1955	0.0412	0.0427	
	(mean)	71.63	(gain)		0.0752			(gain)	(gain)	
	0.05 (gain)				73.6552					

Before Section.

Quantity of air (V′) = 74.8127 at 69°.08—32° = 37.08 = t′.

V + (V × t′ × 0.002035) = V′. V = 70. W = V × 0.08073 = 5.651.

Rise in temp. of air 0.37 = t. Q = W × t × sp. h. = 5.651 × 0.37 × 0.2374 = 0.4963 = heat given to air.

Quotient for box $\frac{74.8127}{0.0937}$ = 798.4 × 0.0509 = 40.6385 grammes = moisture leaving box.

Quotient for air $\frac{74.8127}{0.1067}$ = 701.1 × 0.0236 = 16.5459 grammes = moisture entering box.

24.0926 grammes = moisture vaporized in box.

$\frac{24.0926}{6.2789}$ = 3.837 = heat expended in vaporization.

Rise in temp. of water 1.15 × 164.1414 = 188.7626 = heat given to calorimeter.
3.837 = heat expended in vaporization.
0.4963 = heat given to air.

193.0959 = heat dissipated in 1½ hours.

Hourly heat dissipation 128.7306

After Section.

Air practically unchanged in temperature in its passage through the box.

Quotient for box $\frac{73.6552}{0.0752}$ = 979.4 × 0.0412 = 40.3513 grammes = moisture coming from box.

Quotient for air $\frac{73.6552}{0.1955}$ = 376.7 × 0.0427 = 16.085 grammes = moisture entering box.

24.2663 grammes = moisture vaporized in box.

$\frac{24.2663}{6.2789}$ = 3.865 = heat expended in vaporization.

Rise in temp. of water 1.7 × 164.1414 = 279.0403 = heat given to calorimeter.
0.0 = heat given to air.
3.865 = heat expended in vaporization.

282.9053 = heat dissipated in 1½ hours.

Hourly heat dissipation 188.6035

Summary.

Hourly dissipation of heat after section	188.6035
Hourly dissipation of heat before section	128.7306
Hourly increase of heat dissipation following section	59.8729

Carbonic Acid.

Before Section.

0.016125 × 798.4 = 12.8742 grammes CO_2 leaving box.
0.0055 × 701.1 = 3.8561 grammes CO_2 entering box.

9.0181 grammes = CO_2 produced in 1½ hours.

CO_2 *produced in* 1 *hour* 6.012 grammes.

AFTER SECTION.

0.0155 × 979.4 = 15.1807 grammes CO_2 leaving box.
0.0075 × 376.7 = 2.8252 grammes CO_2 entering box.

12.3555 grammes = CO_2 produced in 1½ hours.
CO_2 produced in 1 hour 8.237 grammes.

SUMMARY.

CO_2 produced hourly after section	8.237	grammes.
CO_2 produced hourly before section	6.012	grammes.
Hourly increase in carbonic acid production following section	2.225	grammes.

EXPERIMENT 28.

A moderate sized poodle dog. Weight 18 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	REMARKS.
12:33 P.M.	82°.5	80°.2	73°.3	102°.2	146.348	73.2068	
1:3	83.5	80.7					Evaporated moisture not noted because the air meter met with an accident which rendered its readings void.
1:18	84.7	81.3					
1:33	84.7	81.6					
1:48	84.7	82.04					
2:3	83.43	81.48					
2:18	83.22	82.04					
2:33	83	83.06	74.72	102.2	295.312	73.5164	
	83.7	81.5	1.42	0.0	148.964	0.3096	
	81.5	(mean)	(gain)		0.3096		
	2.2 (loss)				149.2736		

2:45 P.M.—Cord cut at second dorsal vertebra. 2:47 P.M. Rectal temp. 102°.38. 2:48 P.M. Rectal temp. 103°.3. 3:3 P.M. Rectal temp. 103°.68. 3:10 P.M. Rectal temp. 103°.4

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP (Fah.)	RECT. TEMP (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)
3:48 P.M.	83°.9	83°.8	74°.9	103°	357.41	73.5165
4:2	83	81.9				
4:17	82.2	81.3				
4:32	81.9	81.1				
4:54	81.8	81.1				
5:9	81.6	81				
5:18	81.4	81.2	76.3	96.44	479.61	73.7914
	82.26	81.6	1.4	6.56	122.2	0.2749
	81.6	(mean)	(gain)	(loss)	0.2749	
	0.66 (loss)				122.4749	

BEFORE SECTION.

Quantity of air (V′) = 149.2736 at 81°.5—32° = 49.5 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{V'}{1.1} = 135.7$. $W = V \times 0.08073 = 10.9$.

Fall in temp. of air 2.2 = t. $Q = W \times t \times$ sp. h. = 10.9 × 2.2 × 0.2374 = 5.6928 = heat taken from air.
Rise in temp. of water 1.42 × 164.1414 = 233.0808 = heat given to calorimeter.
5.6928 = heat taken from air.

227.388 = heat dissipated in 2 hours.
Hourly dissipation of heat 113.694

After Section.

Quantity of air (V′) = 122.4749 at 81°.6—32° = 49.6 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{122.4749}{1.1} = 111.3$. $W = V \times 0.08073 = 8.985$

Fall in temp. of air 0.66 = t. $Q = W \times t \times$ sp. h. $= 8.985 \times 0.66 \times 0.2374 = 1.4077$ = heat taken from air.

Rise in temp. of water $1.4 \times 164.1414 = 229.798$ = heat given to calorimeter.

1.4077 = heat taken from air.

228.3903 = heat dissipated in 1½ hours.

Heat dissipated in one hour 152.2602

Summary.

Hourly dissipation of heat after section	152.2602
Hourly dissipation of heat before section	113.694
Hourly increase in dissipation of heat following section	38.5662

Experiment 29.

A cur.—Weight 20 pounds

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Remarks. (grms.)
2:5 P. M.	60°.5	63°.5	67°.5	103°.62	786.61	78.03	16.6123	
2:20	61.8	63.7						
2:35	61.8	64						
2:50	60.9	63.8						CO_2 in sample 0.0337
3:20	61.7	63.3						CO_2 in air 0.00625
3:35	62.3	63.8	68.1	102.56	876.07	78.1414	16.9647	
	61.5 (mean)	63.7 61.5	0.6 (gain)	1.06 (loss)	89.46 0.1114	0.1114*	0.3524	
		2.2 (gain)			89.5714			

3:55 P. M.—Cord cut at sixth cervical vertebra; much blood (5 to 6 ounces) lost.

4:11 P. M.—Rectal temperature 101°.4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Remarks. (grms.)
4:56 P. M.	62°.4	65°.1	69°.44		935.77	78.1924	16.9647	
5:11	63.9	67						
5:26	64.6	66.7						CO_2 in sample 0.02775
5:41	64.4	66.2						CO_2 in air 0.004
5:56	64.04	65.5	70.1	89°.6	992.015	78.404	17.1079	
	63.9 (mean)	66.1 63.9	0.66 (gain)		56.245 0.2116	0.2116	0.1432	
		2.2 (gain)			56.4566			

Before Section.

Quantity of air (V′) = 89.5714 at 63°.7—32° = 31.7 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{89.5714}{1.06} = 84.4$. $W = V \times 0.08073 = 6.8$.

Rise in temp. of air 2.2. $Q = W \times t \times$ sp. h. $= 6.8 \times 2.2 \times 0.2374 = 3.5515$ = heat given to air.

Rise in temp. of water $0.6 \times 164.1414 = 98.4848$ = heat given to calorimeter.

3.5515 = heat given to air.

102.0363 = heat dissipated in 1½ hours.

Hourly dissipation of heat 68.0242

* In some of the experiments detailed in this paper the loss or gain of heat by the vaporization or condensation of moisture was disregarded. The result has not been in any case perceptibly affected thereby.

AFTER SECTION.

Quantity of air (V′) = 56.4566 at 66°.1—32° = 34.1 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{56.4566}{1.07} = 52.7$. $W = V \times 0.08073 = 4.25$

Rise in temp. of air 2.2 = t. $Q = W \times t \times$ sp. h. $= 4.25 \times 2.2 \times 0.2374 = 2.2196$ = heat given to air.

Rise in temp. of water $0.66 \times 164.1414 = 108.3333$ = heat given to calorimeter.

2.2196 = heat given to air.

Heat dissipated in one hour 110.5529

SUMMARY.

Hourly heat dissipation after section 110.5529

Hourly heat dissipation before section 68.0242

Hourly increase in heat dissipation following section 42.5287

Carbonic Acid Calculation.

BEFORE SECTION.

Quotient for box $\frac{89.5714}{0.1114} = 804.0 \times 0.0337 = 27.0948$ grammes = CO_2 leaving box.

Quotient for air $\frac{89.5714}{0.3524} = 254.2 \times 0.00625 = 15.8875$ grammes = CO_2 entering box.

11.2073 grammes = CO_2 produced in 1½ hours.

Hourly production of CO_2 7.4714 grammes.

AFTER SECTION.

Quotient for box $\frac{56.4566}{0.2116} = 266.8 \times 0.02775 = 7.4037$ grammes = CO_2 coming from box.

Quotient for air $\frac{56.4566}{0.1432} = 394.2 \times 0.004 = 1.5768$ grammes = CO_2 entering box.

Hourly production of CO_2 5.8269 grammes.

SUMMARY.

Hourly production of CO_2 before section 7.4714 grammes.

Hourly production of CO_2 after section 5.8269 grammes.

Hourly diminution in the production of CO_2 *following section* 1.6445 grammes.

EXPERIMENT 30.

A cur pup. Weight 16 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)
11:52 A. M.	64°.94	67°.4	64°.64	101°.25	188.642	25.9358	7.2471	127.4098	111.5750
12:5 P. M.	64.31	66.68							
12:20	64.49	66.29							
12:35	64.4	67.02							
12:52	64.76	66.56	65.72	101.25	253.386	26.0248	7.2853	127.4444	111.5836
	64.58 (mean)	66.79	1.08 (gain)	0	64.744	0.089	0.0382	0.0346 (gain)	0.0086 (gain)
		64.58			0.089				
		2.21 (gain)			64.833				

1:10 P. M.—Spinal cord cut between the first and second dorsal vertebræ.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)
1:30 P. M.	65°.48	67°.6	65°.185	101°.75	272.426	26.0248	7.2857	127.4444	111.5836
1:45	65.3	68							
2:6	65.21	67.8							
2:15	65.95	67.9							
2:30	65.96	68.09	66.38	94.25	338.56	26.0968	7.3245	127.4760	111.5942
	65.58 (mean)	67.88	1.195 (gain)	7.5 (loss)	66.134	0.072	0.0388	0.0316 (gain)	0.0106 (gain)
		65.58			0.072				
		2.3 (gain)			66.206				

BEFORE SECTION.

Quantity of air (V′) = 64.833 at 66°.79—32° = 34.79 = t′.

$V + (V \times t' \times 0.002035) = V' = \frac{64.833}{1.07} = 60.6$. $W = V \times 0.08073 = 4.9$

Rise in temp. of air 2.21 = t. $Q = W \times t \times$ sp. h. $= 4.9 \times 2.21 \times 0.2374 = 2.5686$ = heat given to air.

Quotient for box $\frac{64.833}{0.089} = 728.6 \times 0.0346 = 25.2095$ = moisture coming from box.

Quotient for air $\frac{64.833}{0.0382} = 1697 \times 0.0086 = 14.5942$ = moisture entering box.

10.6153 = moisture vaporized in box.

$\frac{10.6153}{6.2789} = 1.6906$ = heat expended in vaporization.

Rise in temp. of water $1.08 \times 164.1414 = 177.2727$ = heat given to calorimeter.
2.5686 = heat given to air.
1.6906 = heat expended in vaporization.

Hourly dissipation of heat 181.5319

AFTER SECTION.

Quantity of air (V′) = 66.206 at 67°.88—32° = 35.88 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{66.206}{1.073} = 61.7$. $W = V \times 0.08073 = 5$

Rise in temp. of air 2.3 = t. $Q = W \times t \times$ sp. h. $= 5 \times 2.3 \times 0.2374 = 2.7301$ = heat given to air.

Quotient for box $\frac{66.206}{0.072} = 919.5 \times 0.0316 = 29.0562$ = moisture leaving box.

Quotient for air $\frac{66.206}{0.0388} = 1706.3 \times 0.0106 = 18.0867$ = moisture entering box.

10.9695 = moisture vaporized in box.

$\frac{10.9695}{6.2789} = 1.747$ = heat expended in vaporization.

Rise in temp. of water $1.195 \times 164.1414 = 196.149$ = heat given to calorimeter.
2.7301 = heat given to air.
1.747 = heat expended in vaporization.

Hourly dissipation of heat 200.6261

SUMMARY

Hourly dissipation of heat following section	200.6261
Hourly dissipation of heat before section	181.5319
Hourly increase of dissipation of heat following section	19.0942

EXPERIMENT 31.

A bitch. Weight 15 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS. (grms.)
1:51 P. M.	77°.6	77°.3	73°.5	103°.2	145.855	0.35	0.9958	146.4048	146.7329	
2	77.4	76.5								
2:21	77.4	76.6								CO_2 in sample 0.00875
2:36	77.2	76.5								CO_2 in air 0.001725
2:51	77.4	76.8	74.23	103.2	206.725	0.4077	1.032	146.4379	146.747	
	77.4	76.74	0.73	0	60.87	0.0577	0.0362	0.0331	0.0141	
	76.74	(mean)	(gain)		0.0577			(gain)	(gain)	
	0.66				60.9277					
	(loss)									

3:15 P. M.—Cord cut in upper dorsal region. 4:02 P. M.—Rectal temperature 106° F.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks. (grms.)
5:17 P. M.	80°.5	78°.7	73°.3	104°	238.028	0.41	1.03	146.4379	146.747	
5:32	79.7	78.1								
5:47	79.8	78.2								CO_2 in sample 0.00338
6:2	79.8	78.6								CO_2 in air 0.00175
6:17	79.7	78.8	74.23	97.5	291.66	0.4286	1.47	146.4581	146.7707	
	79.9	78.48	0.93	6.5	53.632	0.0186	0.44	0.0202	0.0237	
	78.48	(mean)	(gain)	(loss)	0.0186					
	1.42				53.6506					
	(loss)									

Before Section.

Quantity of air (V′) = 60.9277 at 76°.74—32° = 42.74 = t′.

V + (V × t′ × 0.002035) = V′. V = 56. W = V × 0.08073 = 4.52

Fall in temp. of air 0.66 = t. Q = W × t × sp. h. = 4.52 × 0.66 × 0.2374 = 0.6074 = heat taken from air.

Quotient for box $\frac{60.9277}{0.0577}$ = 1056 × 0.0331 = 34.9536 = moisture leaving box.

Quotient for air $\frac{60.9277}{0.0362}$ = 1683 × 0.0141 = 23.7303 = moisture entering box.

11.2233 = moisture vaporized in box.

$\frac{11.2233}{6.2789}$ = 1.7874 = heat expended in vaporization.

Rise in temp. of water 0.73 × 164.1414 = 119.8232 = heat given to calorimeter.

1.7874 = heat expended in vaporization.

121.6106

0.6074 = heat taken from air.

Heat dissipated in one hour 121.0032

After Section.

Quantity of air (V′) = 53.6506 at 78°.48—32° = 46.48 = t′.

V + (V × t × 0.002035) = V′. $V = \frac{53.6506}{1.095}$ = 49. W = V × 0.08073 = 3.956

Fall in temp. of air 1.42 = t. Q = W × t × sp. h. = 3.956 × 1.42 × 0.2374 = 1.3335 = heat taken from air.

Quotient for box $\frac{53.6506}{0.0186}$ = 2885 × 0.0202 = 58.2770 = moisture leaving box.

Quotient for air $\frac{53.6506}{0.44}$ = 122 × 0.0237 = 2.8914 = moisture entering box.

55.3856 = moisture vaporized in box.

$\frac{55.3856}{6.2789}$ = 8.8209 = heat expended in vaporization.

Rise in temp. of water 0.93 × 164.1414 = 152.6515 = heat given to calorimeter.

8.8209 = heat expended in vaporization.

161.4724

1.3335 = heat taken from air.

Heat dissipated in one hour 160.1389

Summary.

Heat dissipated hourly after section 160.1389

Heat dissipated hourly before section 121.0035

Gain in hourly heat dissipation following section 39.1354

Carbonic Acid.

Before Section.

0.00875 × 1056 = 9.24 grammes = CO_2 leaving box.

0.001725 × 1683 = 2.9031 grammes = CO_2 entering box.

CO_2 *produced in an hour* 6.3369 grammes.

After Section.

$0.00338 \times 2885 = 9.7513$ grammes $= CO_2$ leaving box.
$0.00175 \times 1220 = 2.135$ grammes $= CO_2$ entering box.

CO_2 *produced in an hour* 7.6163 grammes.

In studying these experiments it will be seen that in each there was a very decided increase in the throwing off of heat by the animal after division of the cord. In Experiment 26 the cord was cut in its middle region between the second and third dorsal vertebræ, above the origin of the great splanchnic nerves; there was, therefore, vaso-motor paralysis affecting almost the entire trunk and the lower extremities. The hourly increase of heat loss was enormous, equalling one-third of the original amount. In Experiment 28 the cord was cut in very nearly the same place as in the preceding experiment, but the increase of heat dissipation, although decided, was not nearly so great. In Experiment 30 the section was practised one vertebra higher up, but the increase of heat dissipation was comparatively very slight, not amounting to more than 13 per cent. of the original. The animal was, however, a pup, and in this fact probably lies the reason of the comparative poverty of increase. In Experiment 31 the cord was cut in the upper dorsal region, above the origin of the splanchnics, and the increase of heat dissipation amounted to nearly 30 per cent.

In the remaining experiments of the series the cord was divided in the cervical region. In Experiment 25 the division was between the fifth and sixth cervical vertebræ, and the increase of heat dissipation amounted to over 50 per cent. of the original yield. In Experiment 27 the section was practised slightly higher, and although respiration was profoundly affected, the rate of heat dissipation rose over 30 per cent. In Experiment 29 the cord was cut about the same place, at the sixth cervical vertebra, and the increase of heat evolution was over 50 per cent. although considerable blood was lost.

The experiments just detailed would seem to prove that section of the cord is always followed by a decided increase in the giving off of animal heat, and that the amount of the increase is in direct proportion to the nearness of the section to the brain, provided respiration be not seriously interfered with.

The following series of experiments shows, however, that this generalization is at least too sweeping.

Experiment 32.

A small Spitz dog; weight 18 lbs.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)
12:34 P. M.	79°.8	78°.5	78°.18	104°	371.63	77.8258
12:48	79 5	78.7				
1:18	79.3	77.2				
1:34	77.2	78.2				
1:48	78.8	79.5				
2:3	80.2	80				
2:18	80.6	78.8				
2:34	79.5	79.1	78.5	102.3	518.61	77.9098
	79.3	78.7	0.32	1.7	146.98	0.084
	78.7	(mean)	(gain)	(loss)	0.084	
	0.6 (loss)				147.064	

3 P. M.—Cord cut at junction of cervical and dorsal vertebræ.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX. TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)
3:37 P. M.	79°.3	79°	78°.8		544.78	77.9098
4:7						
4:22	78.5	79.4				
4:37	78.2	78.9				
4:52	77.9	78.9				
5:7	77.5	80	79		629.93	78.0445
	78.28 (mean)	79.24	0.2 (gain)		85.15	0.1347
		78.28				85.2847
		0.96 (gain)				

BEFORE SECTION.

Quantity of air (V′) = 147.064 at 78°.7—32° = 46.7 = t′.

$V + (V \times t \times 0.002035) = V'$. $V = \frac{147.064}{1.0951} = 134.3$. $W = V \times 0.08073 = 10.842$

Fall in temp. of air 0.6 = t. $Q = W \times t \times$ sp. h. $= 10.842 \times 0.6 \times 0.2374 = 1.5443$ = heat taken from air.

Rise in temp. of water $0.32 \times 164.1414 = 52.5252$ = heat given to calorimeter.

1.5443 = heat taken from air.

54.0695 = heat dissipated in two hours.

Hourly dissipation of heat 27.0348

AFTER SECTION.

Quantity of air (V′) = 85.2847 at 79°.24—32° = 47.24 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{85.2847}{1.096} = 77.8$. $W = V \times 0.08073 = 6.28$

Rise in temp. of air 0.96 = t. $Q = W \times t \times$ sp. h. $= 6.28 \times 0.96 \times 0.2374 = 1.4315$ heat given to air.

Rise in temp. of water $0.2 \times 164.1414 = 32.8283$ = heat given to calorimeter.

1.4315 = heat given to air.

34.2598 = heat dissipated in $1\frac{1}{2}$ hours.

Hourly dissipation of heat 22.8398

SUMMARY.

Hourly dissipation of heat before section	27.0348
Hourly dissipation of heat after section	22.8398
Decrease of heat dissipation following section	4.195

EXPERIMENT 33.

A cur; weight 17 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECTAL TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS. (grms.)
10:45 A. M.	76°.4	73°.9	70°.3	102°.7	973.185	0.2491	0.7203	70.7463	67	
11	77.5	74.9								
11:15	78.8	75.8								
11:30	79.5	76.2								
11:45	80.6	76.6								CO_2 in sample 0.01475
12 M.	80.7	77.1								CO_2 in air 0.00225
12:15 P. M.	81.2	77.8	71.6	102.2	1051.462	0.3075	0.8052	70.7791	67.0297	
	79.2	76 (mean)	1.3 (gain)	0.5 (loss)	78.277	0.0584	0.0849	0.0328 (gain)	0.0297 (gain)	
	76				0.0584					
	3.2 (loss)				78.3354					

12:50 P. M.—Spinal cord cut in lower dorsal region.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks. (grms.)
1:37 P. M.	80°.3	78°.7	73°.56	104°	109.03	0.3085	0.805	70.77915	67.0297	
1:52	80.8	78.9								
2:7	80.7	79.								
2:22	80.6	79.2								
2:37	80.85	79.4								CO_2 in sample 0.0138
2:52	82	80								CO_2 in air 0.00525
3:7	84.15	80.4	74.79	98	187.06	0.3674	0.995	70.785	67.0753	
	81.3	79.4	1.23	6	78.03	0.0589	0.19	0.00585	0.0456	
	79.4	(mean)	(gain)	(loss)	0.0589			(gain)	(gain)	
	1.9 (loss)				78.0889					

Before Section.

Quantity of air (V′) = 78.3354 at 76°—32° = 44 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{78.3354}{1.0895} = 71.9$. $W = V \times 0.08073 = 5.8$

Fall in temp. of air 3.2. $Q = W \times t \times$ sp. h. $= 5.8 \times 3.2 \times 0.2374 = 4.4061$ heat taken from air.

Quotient for box $\frac{78.3354}{0.0584} = 1341.3 \times 0.0328 = 44.061$ = moisture leaving box.

Quotient for air $\frac{78.3354}{0.0849} = 922.6 \times 0.0297 = 27.4012$ = moisture entering box.

16.6598 = moisture vaporized in box.

$\frac{16.6598}{6.2789} = 2.6533$ = heat expended in vaporization.

Rise in temp. of water $1.3 \times 164.1414 = 213.3838$ = heat given to calorimeter.

4.4061 = heat taken from air.

208.9777

2.6533 = heat expended in vaporization.

211.6310 = heat dissipated in 1½ hours.

Hourly dissipation of heat 141.0873

After Section.

Quantity of air (V) = 78.0889 at 79°.4—32° = 47.4 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{78.0889}{1.096} = 71.2$. $W = V \times 0.08073 = 5.74$.

Fall in temp. of air 1.9 = t. $Q = W \times t \times$ sp. h. $= 5.74 \times 1.9 \times 0.2374 = 2.5897$ = heat taken from air.

Quotient for air $\frac{78.0889}{0.19} = 411 \times 0.0456 = 18.7416$ = moisture entering box.

Quotient for box $\frac{78.0889}{0.0589} = 1325.7 \times 0.00585 = 7.7553$ = moisture leaving box.

10.9863 = moisture condensed in box.

$\frac{10.9863}{6.2789} = 1.75$ = heat gained from condensation.

Rise in temp. of water $1.23 \times 164.1414 = 201.8939$ = heat given to calorimeter.

2.5897 = heat taken from air.

199.3042

1.75 = heat gained from condensation.

197.5542 = heat dissipated in 1½ hours.

Hourly dissipation of heat 131.7028

Summary

Heat dissipated hourly before section	141.0873
Heat dissipated hourly after section	131.7028
Decrease of heat dissipation following section	9.3845

Carbonic Acid.

BEFORE SECTION.

0.01475 × 1341.3 = 19.7984 grammes = CO_2 leaving box.
0.00225 × 922.6 = 2.0758 grammes = CO_2 entering box.

Hourly production of CO_2 17.7226 grammes.

AFTER SECTION.

0.0138 × 1325.7 = 18.2946 grammes = CO_2 leaving box.
0.00525 × 411 = 2.1577 grammes = CO_2 entering box.

Hourly production of CO_2 16.1369 grammes.

SUMMARY.

17.7226 grammes = hourly CO_2 production before section.
16.1369 grammes = hourly CO_2 production after section.

Decrease of CO_2 *production following section* 1.5857

In studying Experiment 32, the feature which first attracts attention is the smallness of the hourly dissipation of heat. This evidently was dependent upon the excessively thick coating of very long hair which covers the Spitz dog, and which must interfere in a very great degree with the throwing off of heat. After section of the cord there was a reduction instead of an increase in the dissipation of heat. I cannot help believing that the excessive coating of hair played an important part in the production of this anomalous result. In Experiment 33, the diminution of heat dissipation only amounted to about 8 per cent. It will be noted that the cord was cut very low down, below the origin of the splanchnic nerves. The discussion of the cause of the discrepancies between the results of these two experiments, and those previously obtained, will be best carried out, after the consideration of the causes of the increased heat dissipation, which usually follows section of the cord. What then is the cause of this increased loss of heat

Tscheschichin, in his experiments (*op. cit.*, pp. 154, 177), found that after section of the cord the temperature in the interior of the body sank more rapidly than that of the external parts; thus, in one experiment, the mercury in two thermometers, which had their bulbs respectively in the intestines and underneath the skin of the animal, differed before the operation in height eight-tenths degree F., whilst some time after the operation they only differed one-tenth degree F.

I have performed and reported elsewhere (*A Study of the Nature and Mechanism of Fever*) a single experiment in which the surface did not maintain its temperature more persistently than did the deep tissues. But in the recent elaborate studies of Henri Parinaud the researches of Tscheschichin have been substantially confirmed. Observations were made with thermometers placed in the rectum, axilla, and groin, and upon the surface of the front and hind feet. It was found that after section of the cord both the rectal temperature and that of the deep parts of the paralyzed portions of the body as measured in the groin or axilla always fell, but the surface temperature underwent a distinct primary transient rise. Section of the cord undoubtedly paralyzes the vaso-motor nerves and dilates the bloodvessels; it makes, therefore, the ways of communication between the outer and inner portions of the body more open and free, and places more upon a level of temperature the

interior and exterior of the organism. It is certain that the normal animal has some method of controlling the loss of bodily heat, at least within certain limits. Modification of the amount of perspiration is in man very influential, but in the dog, the general surface having no perspiratory glands, this factor sinks into insignificance. The only methods which are at the control of the dog for regulating heat loss are through the respiration and through the external circulation. Thus when heat is to be retained, a partially cooled layer is maintained between the inner hot body and the external cold air by shutting off in a measure the circulation from the superficial parts. On the other hand, when the superficial capillaries are dilated, the heated surface rapidly gives up its caloric. After section of the cord, the superficial capillaries cannot be contracted, and as a natural result, the animal, so far as concerns heat dissipation, is purely dependent upon its environment, and an increased loss of heat must occur in a cool atmosphere. Lowered bodily temperature, with increased loss of heat, is the usual and normal result of a section of the cord practised low enough down to cause a wide-spread vaso-motor palsy. In the Spitz dog (Experiment 32) this increased loss did not occur, probably because the extraordinary protection of the body by the very thick outer coat interfered with surface cooling. The extremely minute quantity of heat dissipated by the hairy Spitz has already been indicated. In Experiment 33 there was no decided increase in loss of heat because the cord was cut so low down that a very insignificant portion of the vaso-motor system was affected.

The immediate effects of section of the cord upon the loss of heat having been determined, it seems natural to inquire whether there also is an increased heat production following the operation. Before entering upon this investigation, however, it is well to determine whether the increased dissipation of heat be persistent, or whether it occur only in the few hours immediately following section. It is plain, if the increased loss of heat be permanent, there must be an increased production as well as an increased dissipation of caloric. At first the heat stored up in the body may be drawn upon, but this source of supply is of course soon exhausted, and any increased dispersion then means increased production of heat. The converse of this, however, does not of necessity follow, for it is possible to have a primary increase with a later decrease of production. Thus it is chemically very conceivable, that merely lowered temperature can check tissue change, *i. e.*, production of caloric. It is well known that external heat, by raising the internal temperature, is capable of causing fever, with its excessive metamorphosis of tissue: and it would seem probable that cold checks chemical movements inside as well as outside of the body. The history of hibernating animals is a case in point; in them, with lowered temperature there is lowered chemical activity.

The next experiments were therefore directed to deciding whether the increased dissipation of heat, after section of the cord, is persistent or lasts only a few hours.

Experiment 34.

This experiment is a continuation of Experiment 26.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)
2:17 P. M.	72°.4	77°.3	77°.5	104°	131.42	77.7088
2:32	72.4	77.6				
2:47	73.5	77.8				
3: 2	72.4	78.1				
3:17	72.	78.3				
3:32	71.7	78.5				
3:47	72.2	78.1				
4:17	72.7	78.8	78.9	102.4	303.21	77.826
	72.41 (mean)	78.06	1.4 (gain)	1.6 (loss)	171.79	0.1172
		72.41			0.1172	
		5.65 (gain)			171.9072	

Heat Dissipation.

Quantity of air (V′) = 171.9072 at 78°.06—32° = 46.06 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{171.9072}{1.0937} = 157.1$. $W = V \times 0.08073 = 12.68$

Rise in temp. of air 5.65 = t. $Q = W \times t \times$ sp. h. $= 12.68 \times 5.65 \times 0.2374 = 17.0078$ = heat given to air.

Rise in temp. of water $1.4 \times 164.1414 = 229.798$ = heat given to calorimeter.

17.0078 = heat given to air.

246.8058 = heat dissipated in 2 hours.

Hourly dissipation of heat 123.4029

In comparing the dissipation of heat here recorded with what was yielded before and immediately after section (see page 29), we arrive at the following:—

Before section, hourly dissipation of heat	204.7554
Forty-eight hours after section, hourly dissipation of heat . . .	123.4029
Diminished hourly heat dissipation in second period after section of cord	81.3525
Immediately after section, hourly dissipation of heat	295.1511
Forty-eight hours after section, hourly dissipation of heat . . .	123.4029
Diminished hourly dissipation in second period as compared with first period after section	172.7482

This experiment, taken along with others previously discussed, proves that after section of the cord heat dissipation is usually first increased and afterward diminished. The late diminution of heat dissipation, the temperature of the animal remaining at normal or below it, shows that there is diminished heat production some hours after the section of the cord. The question offers itself, whether, directly after section of the cord, when the dissipation of caloric is abnormally great, the heat production is increased or diminished? In answering this question, it is necessary to remember that all heat dissipated but not produced in a certain period must be obtained by a lowering of the temperature of the body which gives it off. In determining whether the increased dissipation, which follows spinal section, is solely at the expense of the accumulated heat of the body, or whether it is obtained in part by an increased production of heat, it is evidently necessary to know the absolute

amount both of the heat thrown off, and also of that lost by the animal from its bodily store; for the bodily temperature may fall in such a case, but not enough to cover the increased dissipation, and under such circumstances there would be of course increased production of heat. Hereafter in this memoir the heat which is stored up in the animal, will be spoken of as "*heat reserve.*" In calculating its amount, it is necessary to know the specific heat of the organism. Accurate experimental determination of this I have found almost impossible. At first, it seemed sufficient to kill the animal, plunge its body in a known weight of water in a closed wooden vessel, and study the elevation of the temperature of the water and the depression of that of the body. A single experiment showed the fallacy of this method. Chemical operations undoubtedly continue after death, and the amount of heat yielded was so markedly in excess as to show that there was a notable continuous production of the force. Heating the body of an animal long dead might do better, but presents many practical difficulties. To heat the carcass uniformly through is very troublesome, and requires so much time, that chemical changes, coagulation, absorption of water, etc., would with great difficulty, if at all, be avoided. Moreover, as the composition of the body is constantly varying, so must also its specific heat. I have been led by these considerations to despair of any experimental solution of the problem as to the specific heat of animals.

Fortunately, in the present instance, an estimation of the specific heat, sufficiently accurate for our purpose, can be made by taking advantage of the law that the specific heat of a mass is the proportionate mean of the specific heat of its component parts.

According to the generally accepted results of Moleschott 68 per cent. of the body is water; the specific heat of which may be taken as 1. Supposing the specific heat of the remaining dried solids to be that of stone 0.22, the calculated specific heat of the body would be 0.75. This may, I think, be taken as a fair average of the ever varying specific heat of the body. With it the experiments already detailed may be further studied for the purpose of determining whether section of the cord is followed by increased or diminished heat production.

Experiment 25.

Before Section.		
	Heat dissipated hourly	48.0713
	Heat lost from reserve[1] (18 × 1.43 × 0.75)	19.305
	Hourly heat production	28.7663
After Section.		
	Heat dissipated hourly	99.0755
	Heat taken from reserve (18 × 6.25 × 0.75)	84.375
		14.7005

Summary.

Heat produced hourly before section	28.7663
Hourly production of heat immediately after section	14.7005
Hourly loss of heat production following section	14.0658

[1] The formula $Q = w \times t \times$ sp. h. is not repeated here, only the value of the respective factors of the equation being given; t is always taken as the fall or rise of the animal temperature in one hour.

Experiments 26 and 34.

Before Section.

Hourly dissipation of heat	204.7554
Heat added to reserve (25 × 0.53 × 0.75)	9.9375
Hourly production of heat	194.8179

After Section.

First Period—

Record of animal temperature lost and hence calculation impossible.

Second Period—

Heat dissipation	123.4029
Loss from heat reserve (25 × 0.8 × 0.75)	15
	108.4029

Summary.

Hourly heat production before section	194.8179
Hourly heat production 48 hours after section	108.4029
Hourly loss of heat production following section	86.415

Experiment 27.

Before Section.

No change in heat reserve.

Hourly dissipation = hourly production of heat	128.7306

After Section.

Hourly dissipation of heat	188.6035
Loss from heat reserve (32 × 3.05 × 0.75)	73.2
Heat produced hourly	115.4035

Summary.

Heat produced hourly before section	128.7306
Heat produced hourly after section	115.4035
Hourly loss of heat production following section	13.3271

Experiment 28.

Before Section.

No change in heat reserve.

Hourly dissipation = hourly production of heat	113.694

After Section.

Hourly heat dissipation	152.2602
Loss from heat reserve (18 × 4.37 × 0.75)	58.995
	93.2652

Summary.

Hourly production of heat before section	113.694
Hourly production of heat following section	93.2652
Hourly loss of heat production following section	20.4288

Experiment 29.

Before Section.

Hourly dissipation of heat	68.0242
Loss from heat reserve (20 × 0.707 × 0.75)	10.605
Hourly production of heat	57.4192

After Section.

Hourly dissipation of heat	110.5529
Hourly loss from heat reserve (20 × 6.74 × 0.75)	101.1
Hourly production of heat	9.4529

SUMMARY.

Hourly production of heat before section	57.4192
Hourly production of heat after section	9.4529
Hourly loss of heat production following section	47.9663

EXPERIMENT 30.

BEFORE SECTION.

No change in heat reserve.	
Hourly dissipation = hourly production of heat	181.5319

AFTER SECTION.

Hourly dissipation of heat	200.6261
Loss from heat reserve (16 × 7.5 × 0.75)	90
Hourly heat production	110.6261

SUMMARY.

Hourly heat production before section	181.5322
Hourly heat production after section	110.6261
Hourly loss of heat production following section	70.9061

EXPERIMENT 31.

BEFORE SECTION.

No change of heat reserve.	
Hourly dissipation = hourly production of heat	121.0032

AFTER SECTION.

Hourly dissipation of heat	160.1389
Hourly loss from heat reserve (15 × 6.5 × 0.75)	73.125
Hourly production of heat	87.0139

SUMMARY.

Hourly production of heat before section	121.0032
Hourly production of heat after section	87.0139
Hourly loss of heat production following section	33.9893

EXPERIMENT 32.—In this experiment there was diminished heat dissipation, but through neglect the temperature of the body was not taken at the close of the experiment, hence it cannot be determined how far the production of heat was affected.

EXPERIMENT 33.

BEFORE SECTION.

Hourly heat dissipation	141.0873
Loss from heat reserve (17 × 0.33 × 0.75)	4.2075
Hourly heat production	136.8798

AFTER SECTION.

Hourly heat dissipation	131.7028
Loss from heat reserve (17 × 4 × 0.75)	51
Hourly heat production	80.7028

SUMMARY.

Hourly production of heat before section	136.8798
Hourly production of heat after section	80.7028
Hourly loss of heat production following section	56.177

The results in all of these experiments save one are in accord, and in the exceptional case the difference is one of degree and not of kind. Nevertheless the variance is a rather wide one. How it is to be accounted for it is difficult to decide. My own belief is that the experiment was not accurately performed. It was about the third or fourth time I had ever used the calorimeter, and it is very possible that some slight misreading of thermometers may have occurred. Again, the profound disturbance of breathing may have affected the result, or I may not have completely severed the cord. In every experiment there was diminished heat production following the section, the several percentages of loss being as follows: in the 25th experiment, 50 per cent.; 26th, forty-eight hours after section, 41 per cent.; 27th, 10 per cent.; 28th, 18 per cent.; 29th, 83 per cent.; 30th, 40 per cent.; 31st, 28 per cent.; 33d, 41 per cent.; average percentage of loss in the seven experiments (omitting the 27th) 43 per cent.

Leaving out of sight the 27th experiment I think we may consider the following proposition as demonstrated.

Section of the spinal cord above the origin of the splanchnic nerves, is usually followed by an immediate very decided increase in the amount of heat dissipated from the body, and also by a decided lessening of the amount of heat produced.

The known influences which follow section of the spinal cord, capable of affecting the production of heat, are vaso-motor paralysis, lessening of the cardiac force, muscular quiet, diminished respiration, lowering of temperature. Of these, diminished respiration may be left out of the question, because lessened production of heat follows even when the cord has been cut so low down as not to embarrass respiration; muscular quiet seems also of little importance, because the animal in the present series of experiments was always confined in a small dark chamber, and was usually perfectly quiet in the first portion of the comparative experiment, *i. e.*, before section. The lowering of the cardiac force by section of the cord is so indirect and so slight that it is hardly probable that it is a factor of much importance. So that the conclusion seems forced upon us that the primary cause of the lessened heat production is vaso-motor[1] paralysis, which probably acts directly, and also indirectly by causing an excessive loss of heat, and such a lowering of the internal temperature as to check chemical reactions in the body. How general vaso-motor paralysis acts directly upon heat production is easily perceived. A local vaso-motor palsy causes increased and quickened circulation in the part; but a general dilatation of all the vessels produces a sluggishness in the movements of the blood in all parts of the body. It is universally recognized that excessive activity of the circulation in a part tends to produce excessive chemical action, and it seems a logical inference that lessened circulation predisposes to lessened chemical activity.

In order to determine whether the chief role in the diminution of the production

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[1] With these facts known, the reason why in Experiments 42 and 43 there was not increased heat dissipation becomes apparent. In both cases there was a diminished production of heat, and in one case owing to the great protection of the surface of the body by the thick coat, and in the other case to the section of the cord being below the centres which supply the vessels of the surface of the body, the customary rush of heat from within the body to without did not occur, and the diminished production was able to make itself felt in the heat dissipation.

of animal heat is played by the lowering of the internal temperature through excessive dissipation of the heat or by other causes, the following experiments were undertaken.

Experiment 35.

A long-haired bitch, weight 20 pounds.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
12:56 P. M.	73°.3	83°.21	97°.35	102°.38	94.79	27.531	8.216	98.3295	129.2910
1:11	74.12	83.76							
1:26	72 32	83.76							
1:45	71.96	83.36							
1:56			97	104.9	150.443	27.5749	8.2565	98.3505	129.2963
	72.92 (mean)	83.53	0.35 (loss)	2.52 (gain)	55.653	0.0439	0.0405	0.0210 (gain)	0.0053 (gain)
		72.92			0.0439				
		10.61 (gain)			55.6969				

2:10 P. M.—Cord cut at first dorsal vertebra.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
2:40 P. M.	74°.03	87°.44	96°.2	104°.25	184.04	27.575	8.2567	98.3505	129.2963
2:55	74.12	87.75							
3:6	73.1	86.63							
3:25	73	86.18							
3:40	73.64	85.06	95.3	104	233.288	27.7071	8.4183	98.3686	129.3338
	73.58 (mean)	86.61	0.9 (loss)	0.25 (loss)	49.248	0.1321	0.1616	0.0181 (gain)	0.0375 (gain)
		73.58			0.1321				
		13.03 (gain)			49.3801				

Heat Dissipation.

Before Section.

Quantity of air (V′) = 55.6969 at 83°.53—32° = 51.53 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{55.6969}{1.1049} = 50.41$. $W = V \times 0.08073 = 4.07$

Rise in temp. of air 10.61 = t. $Q = W \times t \times$ sp. h. $= 4.07 \times 10.61 \times 0.2374 = 10.2516$ = heat given to air.
Fall in temp. of water 0.35 = t. $Q = 164.1414 \times 0.35 = 57.4495$ = heat lost by calorimeter.

Quotient for box $\frac{55.6969}{0.0439} = 1268.7 \times 0.0210 = 26.6427$ = moisture leaving box.

Quotient for air $\frac{55.6969}{0.0405} = 1375.2 \times 0.0053 = 7.2885$ = moisture entering box.

19.3542

$\frac{19.3542}{6.2789} = 3.082$ = heat expended in vaporization.

10.2516 = heat given to air.
3.0823 = heat expended in vaporization.

13.3339 = heat absorbed by air and in vaporization.
57.4495 = heat lost by calorimeter.
13.3339 = heat absorbed by air and in vaporization.

Heat lost by calorimeter and not accounted for 44.1156

After Section.

Quantity of air (V′) = 49.3801 at 86°.61—32° = 54.61 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{49.3801}{1.111} = 44.4$. $W = V \times 0.08073 = 3.58$.

Rise in temp. of air 13.03 = t. $Q = W \times t \times$ sp. h. $= 3.58 \times 13.03 \times 0.2374 = 11.0741$ = heat given to air.
Fall in temp. of water 0.9 = t. $Q = 164.1414 \times 0.9 = 147.7273$ = heat lost by calorimeter.

Quotient for box $\frac{49.3801}{0.1321} = 373.8 \times 0.0181 =$ 6.7658 = moisture leaving box.

Quotient for air $\frac{49.3801}{0.1616} = 305.6 \times 0.0375 =$ 11.46 = moisture entering box.

4.6942 = moisture condensed in box.

$\frac{4.6904}{6.2789} = 0.7476$ = heat from condensed vapor.

147.7273 = heat lost by calorimeter.
0.7476 = heat gained by condensation.

148.4749
11.0741 = heat given to air.

Heat lost by calorimeter and not accounted for 137.4008

SUMMARY.

Hourly loss of heat by calorimeter after section	137.4008
Hourly loss of heat by calorimeter before section	44.1156
Hourly excess of unaccounted heat loss from calorimeter after section	93.2852

Heat Production.

BEFORE SECTION.

W = 20. Rise of bodily temperature 2.52 = t.

Q = W × t × sp. h. = 20 × 2.52 × 0.75 = 37.8 = heat added to reserve.

AFTER SECTION.

W = 20. Rise of bodily temperature 0. 25 = t.

Q = W × t × sp. h. = 20 × 0.25 × 0.75 = 3.75 = heat added to reserve.

SUMMARY.

Heat added to reserve before section	37.8
Heat added to reserve after section	3.75
Heat added to reserve before section in excess of that after section	34.05
Excess of loss by calorimeter after section	93.2852
Excess of gain of heat reserve before section	34.05
Excess of hourly heat production before section, supposing calorimeter loses heat regularly	59.2352

EXPERIMENT 36.

A dog, weight about 15 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)
12:51 P. M.	70°.76	89°.33	103°.2	103°.1	649.63
1:5	70.52	93.6			
1:20	71.06	94.7			
1:35	71.06	94.7			
1:51	71.87	98	101.9	107.6	691.499
	71.06 (mean)	94.06 71.06	1.3 (loss)	4.5 (gain)	41.869
		23 (gain)			

2:10 P. M.—Cord cut at upper dorsal vertebra. 2:15 P. M.—Rectal temperature 101°.48 F.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)
2:31 P. M.	70°.16	89°.42	104°.3	101°.5	721.125
2:46	68.72	90.68			
3:10	68.12	87.8			
3:16			102.3	104.9	750.18
	69. (mean)	89.3 69	2 (loss)	3.4 (gain)	29.055
		20.3 (gain)			

3:20 P M.—Rectal temperature 104°.9.

BEFORE SECTION.

Quantity of air (V′) = 41.869 at 94°.06—32° = 62.06 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{41.869}{1.126} = 37.2$. $W = V \times 0.08073 = 3$.

Rise in temp. of air 23 = t. $Q = W \times t \times$ sp. h. $= 3 \times 23 \times 0.2374 = 16.3806$ heat given to air.
Fall in temp. of water 1.3 = t. $Q = 164.1414 \times 1.3 = 213.3838$ = heat lost by calorimeter.
16.3806 = heat given to air.

Heat lost in one hour by calorimeter beyond that accounted for } 197.0032

AFTER SECTION.

Quantity of air (V′) = 29.055 at 89°.3—32° = 57.3 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{29.055}{1.117} = 26$. $W = V \times 0.08073 = 2.1$.

Rise in temp. of air 20.3 = t. $Q = W \times t \times$ sp. h. $= 2.1 \times 20.3 \times 0.2374 = 10.1204$ = heat given to air.
Fall in temp. of water $2 \times 164.1414 = 328.2828$ = heat lost by calorimeter.
10.1204 = heat gained by air.

Loss of heat by calorimeter in ¾ hour beyond that accounted for } 318.1624

Hourly loss by the calorimeter beyond that accounted for 424.2165

SUMMARY.

Hourly loss of heat after section in excess of that accounted for	424.2165
Hourly loss of heat before section in excess of that accounted for	197.0032
Hourly excess of unaccounted heat loss from calorimeter after section	227.2133

Heat Production.

Rise in bodily temperature before section 4.5 = t. W = 15.
$Q = W \times t \times$ sp. h. $= 15 \times 4.5 \times 0.75 = 50.625$ = heat added to reserve.

Rise in bodily temperature after section 3.42 in ¾ of an hour = 4.56 per hour. t = 45.6
$W \times t \times$ sp. h. $= 15 \times 4.56 \times 0.75 = 51.3$ = heat added to reserve.

SUMMARY.

Gain in heat reserve after section	51.3	
Gain in heat reserve before section	50.625	
	0.675	
Excess of loss by calorimeter after section		227.2133
Hourly excess of gain of heat reserve before section		0.675
Excess of hourly heat production before section, supposing calorimeter loses heat regularly		226.5383

EXPERIMENT 37.

Dog, weight 21.5 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	RECT. TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:33 P. M.	66°.8	90°.6	102°.65	102°.1	178
12:48	69	92.9			
1:3	69.4	95.4			
1:18	69.8	96.2			
1:33	70	95.8			
1:48	70.2	96	105.44	99.7	271.5
	69.2 (mean)	94.5	2.79 (loss)	2.4 (loss)	93.5
		69.2			
		25.3 (gain)			

3:50 P. M.—Cord cut in upper dorsal region.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:35 P. M.	72°.	94°.1	102°.1	97°.29	303.5
3:50	69.5	91.2			
4:5	68.8	89.5			
4:20	69.9	89.3			
4:35	70.2	88.6	100.1	102.65	401
	70.1 (mean)	90.5	2 (loss)	5.36 (gain)	97.5
		70.1			
		20.4 (gain)			

Before Section.

Quantity of air (V′) = 93.5 at 94°.5—32° = 62°.5 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{93.5}{1.126} = 83$. $W = V \times 0.08073 = 6.7$

Rise in temp. of air 25.3 = t. $Q = W \times t \times$ sp. h. $= 6.7 \times 25.3 \times 0.2374 = 40.2417$ = heat given to air.

Fall in temp. of water $2.4 \times 130.8589^{*} = 314.0614$ = heat lost from calorimeter.

40.2417 = heat given to air.

Heat lost by the calorimeter in $1\frac{1}{4}$ *hours beyond that accounted for* 273.8197

After Section.

Quantity of air (V′) = 97.5 at 90°.5—32° = 58°.5 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{97.5}{1.119} = 87.1$. $W = V \times 0.08073 = 7.03$

Rise in temp. of air 20.4= t. $Q = W \times t \times$ sp. h. $= 7.03 \times 20.4 \times 0.2374 = 34.046$ = heat given to air.

Fall in temp. of water $2 \times 130.8589 = 261.7178$ = heat lost from calorimeter.

34.046 = heat given to air.

Heat lost by the calorimeter in 1 hour beyond that accounted for 227.6718

Heat Production.

Before Section.

$Q = W \times t \times$ sp. h. $= 21.5 \times 2.79 \times 0.75 = 44.9888$ = heat added to reserve.

Heat lost from calorimeter beyond that accounted for	273.8197
Heat added to reserve	44.9888
Heat lost in $1\frac{1}{4}$ hours over and above that produced by animal	228.8309
Hourly loss of heat from calorimeter over and above that produced	183.0647

After Section.

$Q = W \times t \times$ sp. h. $= 21.5 \times 5.36 \times 0.75 = 86.43$ = heat added to reserve.

Heat lost from calorimeter beyond that accounted for	227.6718
Heat added to reserve	86.43
Hourly loss of heat from calorimeter over and above that produced	141.2418

Summary.

Heat lost in 1 hour from calorimeter over that produced before section	183.0647
Heat lost in 1 hour from calorimeter over that produced after section	141.2418
Hourly gain in heat production following section	41.8129

* Three calorimeters were used in this research; their respective thermic equivalents are—No. 1, 164.1414; No. 2, 130.8589; No. 3, 79.544.

Experiment 38.

A long-haired cur, weight 31 lbs.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:47 P. M.	63°.07	88°.34	94°.2	103°.6	867
1:2	69.35	89.87			
1:17	69.71	90.68			
1:32	69.08	90.44			
1:47	68.72	88.28	93.52	104.2	916
	67.99 (mean)	67.99	0.68 (loss)	0.6 (gain)	49
		21.53 (gain)			

2:20 P. M.—Cord cut at first dorsal vertebra; at 3 P. M. dog put in the hot box, and taken out at 3:25 P. M.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:35 P. M.	75°.02	88°.25	93°.7	104°.4	973
3:50	74.6	89.87			
4:5	74.85	89.36			
4:20	72.63	88.04			
4:35	72.32	87.71	93.4	104.2	1011
	73.88 (mean)	88.65	0.3 (loss)	0.2 (loss)	38
		73.88			
		14.77 (gain)			

Heat Dissipation.

Before Section.

Quantity of air (V′) = 49 at 89°.52—32° = 57.52 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{49}{1.117} = 43.86$. $W = V \times 0.08073 = 3.54$

Rise in temp. of air 21.53 = t. $Q = W \times t \times$ sp. h. $= 3.54 \times 21.53 \times 0.2374 = 18.094$ = heat given to air.

Fall in temp. of water $0.68 \times 130.8589 = 88.984$ = heat lost from calorimeter.

18.094 = heat given to air.

Heat lost by calorimeter beyond that accounted for } 70.890

After Section.

Quantity of air (V′) = 38 at 88°.65—32 = 56.65 = t′. $V + (V \times t' \times 0.002035) = V'$.

$V = \frac{38}{1.115} = 34.08$. $W = V \times 0.08073 = 2.751$

Rise in temp. of air 14.77 = t. $Q = W \times t \times$ sp. h. $= 2.751 \times 14.77 \times 0.2374 = 9.646$ = heat given to air.

Fall in temp. of water $0.3 \times 130.8589 = 39.2577$ = heat lost from calorimeter.

9.646 = heat given to air.

Heat lost by calorimeter beyond that accounted for } 29.6117

Heat Production.

Before Section.

$Q = W \times t \times$ sp. h. $= 31 \times 0.6 \times 0.75 = 13.95$ = heat added to reserve.

Heat lost from calorimeter above dissipation	70.890
Heat added to reserve	13.95
Heat lost from calorimeter above that produced	56.940

AFTER SECTION.

$Q = W \times t \times$ sp. h. $= 31 \times 0.2 \times 0.75 = 4.65 =$ heat lost from reserve.

Heat lost from calorimeter beyond that accounted for	29.6117	
Heat lost from reserve	4.65	
Heat lost from calorimeter above that produced	34.2617	
Heat lost from calorimeter above that produced before section		56.94
Heat lost from calorimeter above that produced after section		34.2617
Apparent loss of heat production following section		22.6783

EXPERIMENT 39.

A dog, weight 31.5 lbs.

TIME.	AIR TEMP (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	METER. (cub. ft.)
12:7 P. M.	75°.2	93°.9	99°.65	103°.2	589
12:22	74.4	95.7			
12:37	74.4	95.5			
12:52	73.8	96.7			
1:7	74.1	96.7			
1:22	74.9	96.1	98.3	104.4	713.42
	74.47 (mean)	95.77 74.47	1.35 (loss)	1.2 (gain)	124.42
		21.3 (gain)			

1:45 P. M.—Cord cut in the upper dorsal region.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	METER. (cub. ft.)
2:37 P. M.	75°.9	92°.3	99°.3	103°.1	739
2:52	74.5	91.8			
3:7	74.2	91			
3:22	74	92.4			
3:37	74.4	93.2			
3:52	72.5	93.5	98.3	106	816
	74.25 (mean)	92.36 74.25	1 (loss)	2.9 (gain)	77
		18.11 (gain)			

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V′) = 124.42 at 95°.77—32° = 63.77 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{124.42}{1.13} = 110$. $W = V \times 0.08073 = 8.88$

Rise in temp. of air 21.3 = t. $Q = W \times t \times$ sp. h. $= 8.88 \times 21.3 \times 0.2374 = 44.9028 =$ heat given to air.

Fall in temp. of water $1.35 \times 130.8589 = 176.6595 =$ heat lost from calorimeter

$44.9028 =$ heat given to air.

Heat lost in 1¼ hours from calorimeter beyond that accounted for } 131.7567

Hourly loss from calorimeter beyond that accounted for 105.4053

AFTER SECTION.

Quantity of air (V′) = 77 at 92°.36—32° = 60.36 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{77}{1.123} = 68.6$. $W = V \times 0.08073 = 5.54$

Rise in temp. of air 18.11 = t. $Q = W \times t \times$ sp. h. $= 5.54 \times 18.11 \times 0.2374 = 23.8182 =$ heat given to air.

Fall in temp. of water $1 \times 130.8589 = 130.8589 =$ heat lost from calorimeter.

$23.8182 =$ heat given to air.

Heat lost in 1¼ hours from calorimeter beyond that accounted for } 107.0407

Heat lost in one hour from calorimeter beyond that accounted for 85.6325.

Heat Production.

BEFORE SECTION.

$Q = W \times t \times$ sp. h. $= 31.5 \times 0.96 \times 0.75 = 22.68 =$ heat added to reserve.

Heat lost from calorimeter	105.4053
Heat added to reserve	22.68
at lost from calorimeter beyond that produced	82.7253

AFTER SECTION.

$Q = W \times t \times$ sp. h. $= 31.5 \times 2.32 \times 0.75 = 54.81 =$ heat added to reserve.

Heat lost from calorimeter	85.6325
Heat added to reserve	54.81
Heat lost from calorimeter above that produced	30.8225

SUMMARY.

Heat lost from calorimeter above that produced before section	82.7253
Heat lost from calorimeter above that produced after section	30.8225
Apparent gain of heat production following section	51.9028

In studying the series of experiments just reported, the excessive loss of heat by the calorimeter at once attracts attention. As already stated (page 19), the apparatus when worked at high temperatures is very unsatisfactory, the loss of heat from it being not only very great but also irregular. By the previous use of water at 100° F., and other precautions, the attempt was made to have the calorimeter heated equally throughout, but very careful experimental tests have shown that this is almost impossible, and that all experiments made in the manner of those just recorded must be received with great reserve. The results are, however, so decided as perhaps to be beyond the probable limits of error, especially as they seem coincident with the results obtained by exposing animals to a hot atmosphere before and after section of the cord. It was found that in strong animals the temperature rose faster after section of the cord than before, while in weak animals the reverse was the case. In Experiment 35 the animal temperature rose much faster before than after section, and the production of heat was much less after the operation. The same is true of Experiment 36. In Experiment 37 the hourly rise of rectal temperature was not quite 0.2° F. faster after than before section, and the production of heat 31 units more; in Experiment 38 the animal was very hot when put in the box the second time, and the temperature did not rise materially; this time the heat production was slightly diminished by the section. Finally, in Experiment 39 the rectal temperature rose more than twice as fast after the division of the cord, and the gain of heat production was corresponding.

If these experiments be of any value whatever they show two things: *First.* That the fall of temperature of the body usually following spinal section has a very important effect in lessening the amount of heat produced, *i. e.*, the chemical movements of the body *Second.* That when the effect of the cooling of the body is done away with, section of the cord is sometimes followed by a decreased, sometimes by an increased heat production, and that the latter occurs especially in robust animals. I desire to repeat that these conclusions must be received with

reserve, because we cannot rely upon the working of the calorimeter at a high temperature as accurate.

The conclusions reached, if correct, would indicate that after section of the cord there are two distinct antagonistic forces at work, the one depressing, the other increasing, the production of animal heat. As has already been stated, section of the spinal cord causes vaso-motor paralysis, to which is believed to be due in great part if not altogether the thermic changes in the animal economy which follow the operation. It is of course entirely possible that the thermic changes may be the result of some unknown influences. This could be definitely settled if we had the power to isolate the action of the vaso-motor system by dividing the cord in such a way as to leave intact the vaso-motor nerves whilst severing all other fibres. Since this cannot be done, the question naturally suggests itself: is it possible to cut the spinal cord above the vaso-motor centres; and if this be possible, what is the effect of such division upon the thermic functions of the body? The answering of these questions comes so imperatively into the present inquiry that it is necessary to step aside for a time from what might be considered the direct line of investigation.

The usual test for the integrity of the vaso-motor system is the effect of the galvanization of a sensitive nerve upon the blood pressure after the animal has been quieted with woorara and the pneumogastrics severed. Under these circumstances normally there is a very great rise of arterial pressure, and if this fail to occur vaso-motor paralysis is known to exist.

Dr. C. Dittmar (*Berichte über die Verhandlungen der Königl. Sachs. Gesellschaft der Wissenschaften zu Leipzig. Math. Phys. Classe.* 1870, Bd. xxii.) is the first experimenter to whose original paper I have had access, who proved that, after separation of the medulla from the pons, irritation of a sensitive nerve still causes a great increase of the arterial pressure. Thus in his experiment *a* (p. 33) on a rabbit, the medulla having been previously cut at its junction with the pons, the pressure rose 29 millimetres of mercury in 16 seconds, and in experiment *b*, both peduncles of the crura cerebri having been previously divided, the rise amounted to 30 millimetres.

I. Owsjannikow (*Berichte, etc.*, Bd. xxiii.) has experimented very elaborately, and has found that in cats and rabbits the dominant vaso-motor centre is in a region whose upper boundary is one or two millimetres below the corpora quadrigemina, and whose lower boundary is four to five millimetres above the point of the calamus scriptorius.

Owsjannikow divided the nerve centres with very fine knives, and employed the effect upon the arterial pressure of galvanizing a sensitive nerve as a test of the integrity of the vaso-motor centre. His experiments have every appearance of care and accuracy.

R. Heidenhain (*Pflüger's Archiv*, 1871, Bd. iv. p. 552) has also, in numerous experiments, determined that separation of the medulla from the pons in dogs does not prevent the rise of arterial pressure when a sensitive nerve is irritated.

The results obtained separately by Dittmar, Owsjannikow, and Heidenhain, are

therefore in accord, and indicate that the chief vaso-motor centre is in the medulla oblongata, probably in the exact position indicated by Owsjannikow.

It is true that Prof. Cyon (*Mélanges Biologiques tirés du Bulletin de l'Académie Impériale des Sciences de St. Petersbourg*, t. vii.) found that when the cerebral hemispheres are removed, the medulla oblongata and the cerebellum being left unharmed, irritation of a sensitive nerve is not followed by a rise of arterial pressure. The shock and the bleeding from such an operation are, however, so great that the results of the experiments are of little value; certainly the loss of blood and the nervous disturbance might very conceivably of themselves paralyze the vaso-motor centres, or their controlling influence, if these latter were in the medulla oblongata. Therefore it cannot be allowed that the experiments of Prof. Cyon really contradict those which have just been cited.

Recently the correctness of the conclusion of Dittmar and his corroborators has been further called in question (Dupuy, *Transactions American Neurolog. Society*, 1877), and it seems therefore necessary to report the following records of experiments which entirely confirm those of Dittmar, Owsjannikow, and Heidenhain, and which demonstrate that the chief or governing vaso-motor centre is situated in the lower part of the fourth ventricle.

Experiment 40.

A stout dog. Medulla cut, pneumogastrics severed at 12:20 P. M.

12:30 P. M.—Arterial pressure 120. On galvanizing a sensitive nerve the pressure at first fell, but soon rose to 185, although there were no convulsions or muscular movements except in the few muscles directly tributary to the nerve.

Autopsy.—Medulla nearly severed obliquely at its junction with the pons.

Experiment 41.

A terrier.

1:35 P. M.—Section made; at 3 P. M. the animal breathing quietly, the carotid was connected with the manometer, and the sciatic nerve exposed.

Time.	Arterial Pressure. (Millimetres.)	Irritation.	Remarks.
3:5 P. M.	90–100*	.....	
3:30	90–100	Began.	
3:10	125–120	Ceased.	
3:16	.....	.....	Par vagum cut.
3:21	65–95	.....	
3:24	65–95	Began.	
3:26	120–125	Ceased.	No convulsive movements have been produced by the current except in the distal muscles supplied by the nerve.

Autopsy.—Right half of medulla completely separated at its junction with the pons excepting a small band on each side; left side cut through except a narrow band at the outer edge.

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* The pressure experiments reported in this paper are all of them relative experiments; the gradations are in millimetres, but the zero is different in different experiments, always, however, being uniform throughout each experiment; the numbers do not, therefore, mark absolute amounts of pressure; the *rise* or *fall* is, of course, an absolute quantity.

Experiment 42.

A terrier.

2 P. M.—Section made; 3:55 P. M. kymographion connected with the carotid, the sciatic nerve exposed, and one pneumogastric cut.

Time. M. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	REMARKS.
0	195–200	.....	
0:30	.....	.....	Remaining pneumogastric cut.
1	200–210	.....	
2:30	190–197	Began.	Moderate current.
3	195–200	.....	
3:30	195–200	Ceased.	
4	195–200	.....	
4:30	195–200	.....	
5	194–202	.....	
5:30	196–201	Began.	Current is very intense, full force of Du Bois Reymond coil, with a large (quart) Siemens' and Halske's cell.
6:30	200–203	Ceased.	
7	200–203	.....	
9	.....	.....	Animal killed.

Autopsy.—Medulla wounded deeply upon right side, which is practically destroyed from within about four lines below to one line above the extreme point of calamus.

Experiment 43.

A large dog. The section was made as proven by autopsy just below the point of the calamus, entirely through the right side of the medulla, and more than half through the left side. Galvanization of the sciatic nerve with an intense current had no effect upon blood pressure.

An examination of these experiments will show that they fully confirm those of Dittmar, Owsjannikow, and Heidenhain. In Experiments 41, 42, section was practised entirely above the region of the calamus, and rise of arterial pressure followed upon galvanization of a nerve, as in the normal animal. In Experiments 42, 43, the injury to the nerve centres was within a space of four lines below and above the point of the calamus, and the vaso-motor palsy was complete. I have repeated these experiments at various times with identical results, and the evidence seems to me conclusive that the chief *governing vaso-motor centre is placed in the lower portion of the floor of the fourth ventricle near the point of the calamus.*

The position of the autocratic vaso-motor centre having been determined, the next step in the investigation naturally is a study of the effect of wounds of the medulla, below and above this centre, upon the bodily temperature. The following experiments were performed to determine the results of sections of the medulla which cause vaso-motor palsy.

Experiment 44.

A small rabbit.

Time.	Rect. Temp.	REMARKS.
11:44 A. M.	102°.5 F.	Skull previously bared.
11:45	.....	Section with a very fine tenotome; almost instantaneous fall of temperature.
11:47	99.5	Arterial pressure 92 millimetres; galvanic irritation of the sciatic nerve caused no rise of pressure until the current was so strong as to produce general tetanic contractions; then the mercury rose very slowly 3 millimetres.
11:50	99.5	
12:15 P. M.	.....	Arterial pressure 92 millimetres; the most violent irritation of the sciatic does not affect it.
12:20	93.5	Animal breathing regularly; killed.

Autopsy.—Very few clots; wound a full $\frac{1}{4}$ inch below the lower edge of the cerebellum, nearly severing right half of the cord and wounding the left half.

Experiment 45.

A large dog

Time.	Rect. Temp.	Remarks.
1:45 P. M.	102°.92 F.	Section made.
1:50	103.4	
3:15	94.28	
3:45	.....	Testing arterial pressure shows complete palsy of the vaso-motor system.

Autopsy.—Partial section just below the point of the calamus.

These experiments prove that severe injuries of the medulla below the calamus produce results similar to but greater than those caused by section of the cord, namely, fall of the animal temperature and of the arterial pressure, and confirm the belief that the fall of temperature is due to vaso-motor paralysis.

The effects on the dissipation and production of animal heat of injury either in the immediate neighborhood of, or below the vaso-motor centre having been determined, attention naturally next directs itself to the results produced by wounding the medulla so far above the vaso-motor centre as to avoid injuring it.

Tscheschichin, in a single experiment, found that division of the medulla at its junction with the pons was followed by an immediate and very marked rise of the temperature of the body. J. Bruck and A. Günter (*Pflüger's Archiv*, Bd. iii. p. 579) have also experimented upon the effect of section of the medulla oblongata at the border of the pons on the temperature. They used rabbits, and operated without opening the skull. In seven operations they found that in one the temperature rose enormously after the section, in another it rose very decidedly (1°.1 C.) and in four cases it fell continuously.

I have myself practised a number of experiments of this character, in most cases upon dogs, but in a few instances upon rabbits. I have found it a matter of difficulty to make a clean, complete section of the medulla at its junction with the pons without inducing serious hemorrhage or injuring some other portion of the medulla. The chief trouble lies with the bleeding. The various venous and arterial anastomoses at the base of the brain are always in great danger, and the slightest injury to them invalidates the experiment by causing pressure on the vaso-motor, respiratory, and other important centres. Various methods of experimenting have been practised. Thus, I have tried entering laterally, boring through the skull with a suitable knife, or opening it with a trephine. Again, various attempts have been made to enter through the foramen magnum. At one time a knife, invented by Dr. Lautenbach, acting somewhat on the principle of Bellocque's canula, was employed; the canula being passed up along the medulla through the foramen magnum, and the knife pushed out when sufficiently far in. A thorough trial demonstrated that this plan is impracticable. All other methods of operating were finally abandoned for the following:—

With a small trephine open the skull in the triangular space below the occipital protuberance, so as to enter between the diverging branches of the great longitudinal sinus. Then have the head of the animal firmly held vertically with the nose downwards, pass a narrow dull-pointed knife in, and when sufficiently entered bend

the handle forward so as to direct the point of the knife against the base of the skull, taking care in doing this to throw the point of the knife to one side so as to avoid the basilar artery. Having steadied the knife against the skull, withdraw the point one or two lines so as to avoid the meningeal vessels, and make a sweeping cut. By this procedure the medulla is readily separated from the pons, but no care can ensure the basilar vessels from injury. The cerebellum is of course wounded to some extent, but my experience shows that this has no influence upon the result so far as the thermic or other appreciable symptoms are concerned.

The following experiments exemplify the effect of section of the medulla high up, upon animal temperature.

Experiment 46.

A large powerful mongrel dog.

Time.	Rect. Temp.	REMARKS.
12 M.	102°.25 F.	
12:20 P. M.	.....	Since last note, the skull has been opened above the foramen magnum with a trephine; in doing this a sinus has undoubtedly been wounded, as the dog has lost fully three-quarters of a pint of blood. I have just severed the medulla.
12:25	103.25	
12:30	103.75	
12:40	104	Breathing regular.
12:50	104.50	
1	104.75	
1:10	105.25	
1:30	105.50	Thermometer put into the abdominal cavity.
2	.....	Cardiometer connected with the femoral artery. Arterial pressure 75; upon galvanization of a sensitive nerve it fell to 50. The pneumogastric nerves were next cut; pressure after this was 45–55; on galvanization of a sensitive nerve the pressure rose to 65. The breathing was very much affected, and paralysis both of sensation and motion seemingly complete. Animal killed.

Autopsy.—Medulla oblongata divided at its junction with the pons. Cerebellum wounded.

Experiment 47.

A very powerful long-haired dog.

Time.	Rect. Temp.	REMARKS.
2:18 P. M.	106°.8 F.	Dog has been struggling and fighting most violently, hence his high temperature.
2:19	.....	Section made.
2:25	107.8	
2:30	106.9	
2:35	107.0	
2:50	107.4	
3	107.9	Dog killed.

Autopsy.—Left side of the medulla separated from the pons, except the anterior fibres. Right side, superior one-quarter cut through.

Experiment 48.

A terrier bitch of moderate size and strength.

Time.	Rect. Temp.	Remarks.
11:45 A. M.		
11:47	103°.25 F.	Cut the medulla. Breathing at once ceased almost entirely, so that the dog was at one time thought to be dead, and artificial respiration, by compressing the body with the hand, was resorted to.
11:53	.....	Dog beginning to breathe voluntarily, conjunctiva not sensitive, complete paralysis of sensation and motion throughout the body.
11:54	103.50	Temp. of room 70°.
11:60	103.75	
12:15 P. M.	103.75	Dog shows no other signs of life than the slow, regular breathing.
12:30	103.75	
12:40	104.	
12:45	104.25	Breathing noisy, irregular.
12:55	104.75	General muscular rigidity, with frequent convulsions and tremor; both symptoms are much aggravated by any irritation of the surface. Legs stiffly extended, tail forcibly drawn down between them.
1:15	106.	Temp. of room 70°.
2:10	107.75	Thermometer is now in abdominal cavity (has been in the rectum). The dog has been vomiting freely.
2:15	.....	Arterial pressure 150–160; galvanization of a nerve caused it to fall to 120–125.
2:20	108.135	Cut the par vagum. Breathing at once almost suspended.
2:22	.....	Respiration only at very long intervals. Blood in arteries venous. On connecting a cardiometer tube with the femoral, the mercury rose to the top of the tube (205) and flowed over in abundance.
2:25	.....	There has been no breathing for some minutes. Heart has not ceased to beat.

Autopsy.—Knife has passed through the cerebellum, scraping the posterior surface of upper portion of medulla, and cutting it very obliquely at its junction with the pons.

In looking over the records of these experiments, it will be found that they appear very conclusive, in regard to the rise of temperature which follows division of the medulla high up. One of the most powerful means of lowering the temperature at our command is venesection, and yet, although the dog in Experiment 46 was almost bled to death, the temperature rose from the time the medulla was divided. In Experiment 47 the animal temperature was extraordinarily high, and yet the temperature began to rise at once after the operation. In Experiment 48 no bleeding of any moment occurred, and the elevation of temperature was therefore more marked than in the first trial. The rise commenced immediately after the division of the medulla, and amounted to almost five degrees, and was still increasing when the animal died. As the temperature of the surrounding air in both cases was not over seventy, the evidence is conclusive.

In neither case were the vaso-motor centres paralyzed. In the first experiment, after division of the par vagum, galvanization of a sensitive nerve was followed by a slight but distinct rise of the arterial pressure. The reason that this rise was so slight was probably the very small amount of blood in the vessels consequent upon the hemorrhage, so that contraction of the arteries was not followed by its usual effects.

In the smaller dog, the evidence that the general vaso-motor system was intact, was unimpeachable. At first, the galvanization of a sensitive nerve reduced the pressure, very decidedly, on account of its influence on the par vagum and the heart.

The amount of the arterial pressure was, however, sufficient to prove the integrity of the vaso-motor system, for if the vessels had all been dilated, the mercury in the tube of the manometer could certainly not have stood where it did. Whenever asphyxia is produced in the normal animal, an enormous rise of arterial pressure results, chiefly from vaso-motor spasm caused by the excess of carbonic acid in the blood. The great rise of pressure (from 120 to 205) which followed arrest of respiration in Experiment 48 is positive proof of the section having been made above the vaso-motor centre. The following experiment is confirmatory of the preceding one.

Experiment 49.

A stout young dog above medium size.

Time.	Rect. Temp.	REMARKS.
10:30 A. M.	103°.25 F.	
10:50	.....	Brain opened with slight hemorrhage.
10:55	104.12	
11:5	104.12	
11:20	104.37	
11:35	103.12	Medulla cut. Absolute paralysis of motion and of sensation at once developed.
11:37	103	
12 M.	103	
12:30 P. M.	103	Arterial pressure 120; on galvanizing the nerve the pressure fell at first but soon rose to 185, no movements except in muscles supplied by nerve were elicited.
1	101.75	
1:20	101	
1:25	.....	Dog put in a box at a temperature of 90°.
1:45	101.37	Temperature of box 102°.
2:30	104.25	Temperature of box 104.
2:45	104.50	Temperature of box 90.
3	105	Temperature of box 88.
3:30	106.50	Temperature of box 94.
4	107	Temperature of box 84.
4:30	107	Temperature of box 82.
4:40	107	Temperature of box 76.
5:30	107	Temperature of box 72.
8	106	Temperature of box 64.
8:30	105	Temperature of box 64.
9	105	Temperature of box 64.
		Next morning the dog was found dead.

Autopsy.—Medulla was nearly severed obliquely, where it merged into the pons.

In this case, though there was a primary fall of temperature, the fever, when developed, was independent of the external heat, for whilst the latter was steadily falling from 104° to 72°, the animal heat rose from 104° to 107°. In this experiment the arterial pressure rose from 120 to 185, when a sensitive nerve was galvanized, and the vaso-motor system was therefore intact.

Upon dogs I have performed a number of other experiments similar to those just detailed, with a like result, but in a half dozen or more trials upon rabbits I have not once obtained a distinct permanent rise of temperature after section of the upper medulla. As examples of these experiments the following are submitted:—

Experiment 50.

A rabbit.

Time.	Rect. Temp.	Remarks.
11:20 A. M.	.....	Skull opened.
11:25	103° F.	
11:29	.....	Section of brain made; most violent convulsions came on and lasted a minute or two.
11:30	103.5	
11:32	104	Animal quiet.
11:34	.....	Respiration ceased.
11:35	103.25	

Autopsy.—Wound of brain above the pons. One of the crura cerebri cut through entirely excep a shred, the other crus wounded. A large clot at base of brain running into the fourth ventricle.

Experiment 51.

A rabbit.

Time.	Rect. Temp.	Remarks.
12 M.	.....	Skull opened.
12:50 P. M.	105° F.	Rabbit purging.
12:8	.....	Brain operated upon.
12:10	105	
12:13	105.75	Temperature of room 70°.
12:21	105	
12:25	104.5	Rabbit purging.
12:28	104.5	
12:35	104	
12:45	104	
2:5	105.75	Rabbit lying in the sun, temperature of room 78°. Rabbit put in the shade.
2:22	105.75	
2:23	.....	Violent convulsions lasting a minute, followed by death.

Autopsy.—Incision nearly dividing pons and medulla at their junction, edge of the incision not more than a millimetre from the Owsjannikow's space.

Experiment 52.

A rabbit.

Time.	Rect. Temp.	Remarks.
4:28 P. M.	104°.5 F.	
4:30	.....	Puncture of the left side of the brain through the skull.
4:33	104.75	Animal apparently completely paralyzed, not convulsed.
4:36	104.85	
4:41	104.75	
4:50	104.5	Violent persistent clonic spasm of the left side of the neck.
5:15	103	
5:40	102	
9	95	Animal died during the night.

Autopsy.—A clean incision running obliquely through the pons reaching above almost to its upper surface, below to within about a line of the lower surface.

It will be seen that these experiments, along with those of Bruck and Günter, show that it is an exceptional circumstance to get a rise of temperature in the rabbit after section of the medulla at its junction with the pons. I have also found that in the dog very frequently the rise does not occur, or is not permanent. This certainly in many and possibly in all cases is due to the formation of a clot in the

fourth ventricle, and consequent paralysis by pressure of the vaso-motor centres. The following experiment will serve as an example:—

Experiment 53.

A moderate sized dog.

Time.	Rect. Temp.	Remarks.
10:45 A. M.	.....	Opened the skull.
10:57	102°.5 F.	
11:6	.....	Cut the medulla.
11:10	102.65	Perfect paralysis; breathing nearly suspended.
11:12	102.76	
11:18	103	Breathing regular; entire paralysis.
11:27	102.87	
12:15 P. M.	101.75	
12:30	101.5	
12:45	101.25	
1	100.75	
1:30	100	
2	99.75	
3	97.25	
4:20	97.75	Galvanic current applied to the exposed sciatic nerve slows the pulse, blood pressure not decidedly affected.
4:40	.....	Par vagum cut.
4:45	.....	Current applied to freshly exposed femoral nerve, unless sufficiently violent to cause general tetanus, has no effect upon the blood pressure.
5:15	.....	Current applied to a freshly exposed sciatic nerve, result as before; under a very violent current the dog showed signs of feeling.
6:10	.....	Current again applied; no result.

Autopsy.—Section just at the junction of pons and medulla, leaving on each side a portion of tissue uncut, a fragment of bone lying upon the cerebellum and pressing it down upon the medulla. The whole of the fourth ventricle occupied with a firm clot pressing upon and separating all the parts.

The progress of this experiment is very instructive. In beginning, the vaso-motor centre was not implicated, and the bodily temperature began to rise. Subsequently a clot formed, and slowly annihilated by pressure the function of the vaso-motor centre. With the progressive vaso-motor paralysis the temperature of the body fell, at first slowly and then rapidly. When, as was proven by experimental test, the vaso-motor palsy was complete, the degree of bodily heat was far below the normal.

In searching for the reason that in rabbits separation of the medulla from the pons is so seldom followed by an increase of the animal temperature, paralysis of the vaso-motor centres by direct injury, shock, or hemorrhagic pressure at once suggests itself. The rabbit is so small an animal that the distance between the space assigned by Owsjannikow as containing the vaso-motor centre and the border of the pons cannot be more than a tenth of an inch. It is therefore very evident that to avoid wounding or influencing the vaso-motor centre, in dividing the medulla high up, is in the rabbit an exceedingly difficult and indeed almost impossible task.

In conclusion, the following propositions may be considered as expressing the demonstrations of the preceding experiments upon the effect of section of the medulla on animal temperature.

Injuries of the medulla, so situated as to paralyze the medullary vaso-motor centres, are followed by a very decided fall of animal temperature.

Section of the medulla at the line of its junction with the pons, in the dog usually leads to an elevation of animal temperature, if the medullary vaso-motor centres are not in any way compromitted.

The rise and fall of animal temperature following sections of the medulla may be due to alterations of heat production or of heat dissipation. To determine this the following experiments have been performed.

The first series were undertaken to determine the effect of injuries which cause paralysis of the vaso-motor centres.

Experiment 54.

A large cur, weight 26.25 pounds.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:25 P. M.	70°.16	74°.8	72°.36	102°.92	828.057
12:40	69.32	75.47			
12:55	67.46	73.3			
1:10	69.44	73.76			
1:25	69.2	73.45	72.59	102.92	906.04
	69.12 (mean)	74.16	0.23 (gain)	0	77.983
		69.12			
		5.04 (gain)			

1:45 P. M.—Section made, followed by paralysis, which was complete, except that one leg was occasionally slightly moved 1:50 P. M.—Rectal temperature 103° F.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
2:15 P. M.	70°.34	73°.68	71°.78		943.64
2:30	70.25	73.68			
2:45	70.04	74.12			
3	70.25	73.76			
3:15	70.97	74.66	72.41	94°.28	1023.074
	70.37 (mean)	73.98	0.63 (gain)		79.434
		70.37			
		3.61 (gain)			

3:30 P. M.—Animal still breathing well: the kymographion was connected with the carotid, the pneumogastrics cut and the sciatic exposed; galvanization of the sciatic had no influence upon blood pressure, although a very powerful current was used. The dog was killed some time later.

Autopsy.—The section was through the medulla, just below the point of the calamus. The right side was cut through completely, the left more than half through.

Heat Dissipation.

Before Section.

Quantity of air (V′) = 77.983 at 74°.16—32° = 42.16 = t′. $V + (V \times t' \times 0.002035) = V'$.

$V = \frac{77.983}{1.086} = 71.8$. $W = V \times 0.08073 = 5.8$

Rise in temp. of air 5.04 = t. $Q = W \times t \times$ sp. h. $= 5.8 \times 5.04 \times 0.2374 = 6.9397$ = heat given to air.

Rise in temp. of water $0.23 \times 164.1414 = 37.7525$ = heat given to calorimeter.

6.9397 = heat given to air.

Hourly dissipation of heat 44.6922

After Section.

Quantity of air (V′) = 79.434 at 73°.98 − 32° = 41.98 = t′. $V + (V \times t' \times 0.002035) = V'$.

$V = \frac{79.434}{1.085} = 73.2$. $W = V \times 0.08073 = 5.91$

Rise in temp. of air 3.61 = t. $Q = W \times t \times$ sp. h. $= 5.91 \times 3.61 \times 0.2374 = 5.065$ = heat given to air.

Rise in temp. of water $0.63 \times 164.1414 = 103.4091$ = heat given to calorimeter.

5.065 = heat given to air.

Hourly dissipation of heat 108.4741

Summary.

Hourly dissipation of heat after section	108.4741
Hourly dissipation of heat before section	44.6922
Gain in hourly dissipation of heat following section	63.7819

Heat Production.

Before Section.

No change in bodily temperature.

Hourly heat dissipation = hourly heat production 44.6922.

After Section.

Fall in temperature of animal in 85 minutes 8°.72.

Fall in temp. per hour 6.156 = t. W = 26.25.

$Q = W \times t \times$ sp. h. $= 26.25 \times 6.156 \times 0.75 = 121.1963$* = heat drawn from reserve.

Heat drawn from reserve	121.1963
Heat dissipated hourly	108.4741
Heat lost from reserve over and above that accounted for	12.7222

Summary.

Heat production before section	44.6922
Heat lost from reserve after section above that accounted for	12.7222
Difference in heat production before and after section	57.4144

Experiment 55.

A terrier bitch. Weight 16.25 pounds.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp (Fah.)	Gen. Meter. (cub. ft.)
12:50 P. M.	69°.44	68°.72	61°.997	101°.84	675.605
1:10	69.68	67.79			
1:30	65.48	66.68			
1:40	66.38	66.68			
1:50	.....	.....	63.1256	101.84	758.425
	67.75	67.47	1.1286	0	82.82
	67.47	(mean)	(gain)		
	0.28 (loss)				

2 P. M.—Section made. The trephine slipped and wounded the nerve centres. 2:3 P. M.—Rectal temperature, 104°; 2:10 P. M., rectal temperature, 102°.92; 2:20 P. M., rectal temperature, 102°.92.

* This is probably excessive, because the cooling of the animal was almost certainly more rapid directly after the temperature in the rectum was taken than it was later.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
2:35 P. M.	66°.2	66°.47	62°.72		795.575
2:50	66.08	67.43			
3:5	65.96	67.12			
3:20	68.36	67.02			
3:35	64.76	68.09	63.50	100°.13	860.32
	66.27 (mean)	67.23	0.78 (gain)		64.745
		66.27			
		0.96 (gain)			

3:55 P. M.—Carotid connected with the kymographion, the sciatic having been exposed, and one pneumogastric cut.

Time. M. Sec.	Arterial Press. (Millimetres.)	REMARKS.
0	195–200	
0:30	.....	Remaining pneumogastric cut.
1	200–210	
2:30	190–197	Moderate galvanic irritation of the sciatic commenced.
3	195–200	
3:30	195–200	Irritation ceased.
4	195–200	
4:30	195–200	
5	194–202	
5:30	196–201	Very powerful galvanic current applied to the sciatic.
6:30	200–203	Irritation ceased. Muscular contractions caused by the current abundantly sufficient to account for the slight rise of the arterial pressure.
7	200–203	

Autopsy.—Two wounds of medulla, each upon the right side, the left half being uninjured; lower wound the more extensive, situated about four lines above the point of the calamus, and extending half-way to the centre. There was considerable effused blood in the brain, but no distinct clots.

Heat Dissipation.

Before Section.

Quantity of air (V′) = 82.82 at 67°.47—32° = 35.47 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{82.82}{1.072} = 77.3$. $W = V \times 0.08073 = 6.24$

Fall in temp. of air 0.28 = t. $Q = W \times t \times$ sp. h. $= 6.24 \times 0.28 \times 0.2374 = 0.4148$ = heat taken from air.

Rise in temp. of water $1.1286 \times 164.1414 = 185.25$ = heat given to calorimeter.

0.4148 = heat taken from air.

Heat dissipated in one hour 184.8352

After Section.

Quantity of air (V′) = 64.745 at 67°.23—32° = 35.23 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{64.745}{1.072} = 60.4$. $W = V \times 0.08073 = 4.88$

Rise in temp. of air 0.96 = t. $Q = W \times t \times$ sp. h. $= 4.88 \times 0.96 \times 0.2374 = 1.1122$ = heat given to air.

Rise in temp. of water $0.78 \times 164.1414 = 128.0303$ = heat given to calorimeter.

1.1122 = heat given to air.

Heat dissipated in one hour 129.1425

Summary.

Hourly dissipation of heat before section	184.8352
Hourly dissipation of heat after section	129.1425
Hourly diminution of heat dissipation following section	55.6927

Heat Production

BEFORE SECTION

Loss of heat from bodily reserve none.

Hourly heat dissipation = hourly heat production 184.8352

AFTER SECTION.

Fall of bodily temperature in $1\frac{1}{4}$ hours 2.79, in 1 hour 2.232 = t.

Q = W × t × sp. h. = 16.25 × 2.232 × 0.75 = 27.2025 = loss of heat from reserve.

Hourly dissipation of heat	129.1425
Loss of heat from reserve	27.2025
Hourly production of heat	101.94

SUMMARY.

Hourly production of heat before section	184.8352
Hourly production of heat after section	101.94
Diminution of heat production following section	82.8952

When the medulla is injured in such a way as to paralyze the vaso-motor centres, thermic symptoms similar to those caused by section of the cord would naturally be looked for. In Experiment 54 such symptoms were actually present, the heat dissipation being primarily increased and the heat production diminished. On the other hand, in Experiment 55 the result was not altogether in accord with the preconception. Heat production certainly was diminished, but heat dissipation so far from being increased was actually lessened. The medulla was not, however, completely severed, one-half of it indeed being uninjured. It is, therefore, very probable that the vaso-motor paralysis was not complete, sufficient of the nerve fibres remaining intact to allow of some regulation of heat dissipation by the organism. That increased heat dissipation follows immediately upon complete vaso-motor palsy is very strongly indicated by the immediate and very rapid fall of bodily temperature which occurred in Experiments 44 and 45 when the knife was plunged into the vaso-motor centre.

From all the evidence it seems to me that we are justified in concluding that *wounds of the medulla so situated as to paralyze the vaso-motor centres cause decreased heat production with* (certainly sometimes and probably always) *primarily increased heat dissipation.*

The next series of experiments were directed to the determination of the effect upon calorification, of section of the medulla at its junction with the pons. The experiments are as follows:—

EXPERIMENT 56.

A terrier bitch. Weight 17.25 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)
11:35 A. M.	71°.9	73°.1	74°.4	102°.2	378.79	0.4422	1.503
11:50	72.65	73.4					
12:5 P. M.	73	73.4					
12:20	73.4	73.45					
12:35	74.08	74.1					
12:50	75.2	74.5					
1:5	75.2	74.5	75.42	103.28	451.78	0.5076	1.5563
	73.63 (mean)	73.78	1.02 (gain)	1.08 (gain)	72.99	0.0654	0.0533
		73.63			0.0654		
		0.15 (gain)			73.0554		

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1:25 P. M.—Medulla cut. Rectal temperature at once rose.

1:33 P. M.—Rectal temperature 104°. No apparent sensibility; breathing good; violent rolling movements towards the right; very marked convergent downward strabismus, with constant oscillations of the eyeballs. Pupils widely dilated.

1:40 P. M.—Rectal temp. 103°.64. 1:51 P. M.—Temp. 103°.64. 2 P. M.—Temp. 103°.8. 2:15 P. M.—Temp. 103°.8. 2:30 P. M.—Temp. 103°.9.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)
2:45 P. M.	78°	77°.1	75°	103°.9	484.22	0.5101	1.5631
3	77.4	76.8					
3:15	78.44	77.18					
3:30	78.44	77.36					
3:45	78.3	77.44					
4	78	77.18					
4:15	.....	.....	76.34	102.92	556.74	0.5794	1.644
	78.1	77.18	1.34	0.98	72.52	0.0693	0.0809
	77.18	(mean)	(gain)	(loss)	0.0693		
	0.92 (loss)				72.5893		

5 P. M.—Rectal temperature 103°.64. Animal killed.

Autopsy.—Medulla at the right side where it joined the pons cut through except a thread. Left side about three-fourths cut through; no hemorrhage perceptible.

Before Section.

Quantity of air (V′) = 73.0554 at 73°.78—32° = 41.78 = t′.

$V + (V \times t \times 0.002035) = V'$. $V = \frac{73.0554}{1.085} = 67.3$. $W = V \times 0.08073 = 5.43$

Rise in temp. of air 0.15 = t. $Q = W \times t \times$ sp. h. $= 5.43 \times 0.15 \times 0.2374 = 0.1934$ = heat given to air.

Rise in temp. of water $1.02 \times 164.1414 = 167.4242$ = heat given to calorimeter.

0.1934 = heat given to air.

167.6176 = heat dissipated in 1½ hours.

Hourly dissipation of heat 111.7451

After Section.

Quantity of air (V′) = 72.5893 at 77°.18—32° = 45.18 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{72.5893}{1.092} = 66.5$. $W = V \times 0.08073 = 5.4$

Fall in temp. of air 0.92 = t. $Q = W \times t \times$ sp. h. $= 5.4 \times 0.92 \times 0.2374 = 1.1794$ = heat taken from air.

Rise in temp. of water $1.34 \times 164.1414 = 219.9495$ = heat given to calorimeter.

1.1794 = heat taken from air.

218.7701 = heat dissipated in 1½ hours.

Hourly dissipation of heat 145.8468

Summary.

Hourly dissipation of heat after section	145.8468
Hourly dissipation of heat before section	111.7451
Hourly increase in dissipation of heat following section	34.1017

Heat Production.

Before Section.

Gain of bodily heat 1.08 = t. W = 17.25.

$Q = W \times t \times$ sp. h. $= 17.25 \times 1.08 \times 0.75 = 13.9725$ = heat gained by body in 1½ hours.

Hourly addition to heat reserve = 9.315

Hourly dissipation of heat	111.7451
Heat added hourly to reserve	9.315
Hourly heat production	121.0601

AFTER SECTION.

Fall of bodily temperature in 1½ hours 0.92, in 1 hour 0.61 = t.

Q = W × t × sp. h. = 17.25 × 0.61 × 0.75 = 7.8934 = hourly loss of heat from reserve.

Hourly dissipation of heat	145.8468
Hourly loss from heat reserve	7.8934
Hourly heat production	137.9534

SUMMARY

Heat production after section	137.9534
Heat production before section	121.0601
Hourly increase of heat production after section	16.8933

EXPERIMENT 57.

A dog. Weight 18.5 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)
2:18 P. M.	79°.9	79°.8	78°.92	102°.56	653.86	0.5918	1.6445
2:33	79.6	79.7					
2:48	79.6	79.6					
3:3	79.2	79.6					
3:18	.....	.....	79.31	100.76	703.39	0.63965	1.7872
	79.57 (mean)	79.67 79.57	0.39 (gain)	1.8 (loss)	49.53 0.0478	0.04785	0.1427
		0.1 (gain)			49.5778		

3:26 P. M.—Pons cut. 3:29 P. M.—Rectal temperature, 101°.84.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)
4:18 P. M.	79°.9	79°.9	80°.7	101°.84	743.11	0.6399	1.7872
4:33	80.6	80.8					
4:48	80	80.7					
5:3	80	80.55					
5:18	79.5	80.24	81.49	101.12	790.865	0.6933	1.8916
	80 (mean)	80.44 80	0.79 (gain)	0.72 (loss)	47.755 0.0534	0.0534	0.1044
		0.44 (gain)			47.8084		

Post-mortem.—Medulla severed at its junction with the pons. A large clot of blood upon the pons.

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V′) = 49.5778 at 79°.67—32° = 47.67 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{49.5778}{1.097} = 45.2$. $W = V \times 0.08073 = 3.65$

Rise in temp. of air 0.1 = t. Q = W × t × sp. h. = 3.65 × 0.1 × 0.2374 = 0.087 = heat given to air.

Rise in temp. of water 0.39 × 164.1414 =	64.0151 = heat given to calorimeter.
	0.087 = heat given to air.
Hourly dissipation of heat	64.1021

After Section.

Quantity of air (V′) = 47.8084 at 80°.44—32° = 48.44 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{47.8084}{1.098} = 43.5$. $W = V \times 0.08073 = 3.5$

Rise in temp. of air 0.44 = t. $Q = W \times t \times$ sp. h. $= 3.5 \times 0.44 \times 0.2374 = 0.3656$ = heat given to air.

Rise in temp. of water $0.79 \times 164.1414 = 129.6717$ = heat given to calorimeter.

0.3656 = heat given to air.

Hourly dissipation of heat 130.0373

Summary.

Heat dissipated hourly after section	130.0373
Heat dissipated hourly before section	64.1021
Hourly increase of heat dissipation following section	65.9352

Heat Production.

Before Section.

Fall of temperature of body 1.8 = t. W = 18.5

$Q = W \times t \times$ sp. h. $= 18.5 \times 1.8 \times 0.75 = 24.975$ = heat lost from reserve in one hour.

Heat dissipated in 1 hour	64.1021
Heat lost from reserve	24.975
Hourly heat production	39.1271

After Section.

Fall of temperature of body 0.72 = t. W = 18.5

$Q = W \times t \times$ sp. h. $= 18.5 \times 0.72 \times 0.75 = 9.99$ = heat lost from reserve in one hour.

Heat dissipated in 1 hour	130.0373
Heat lost from reserve	9.99
Hourly heat production	120.0473

Summary.

Hourly production of heat after section	120.0473
Hourly production of heat before section	39.1271
Hourly increase of heat production following section	80 9202

Experiment 58.

A terrier. Weight 16.75 pounds.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:15 P. M.	58°.61	64°.49	62°.36	101°.84	416.03
12:30	59.14	65.96			
12:45	59.42	65.72			
1	59.73	66.08			
1:15	.....	.....	63.068	101.84	502.9
	59.22 (mean)	65.56	0.708 (gain)	0	86.87
		59.22			
		6.34 (gain)			

1:35 P. M.—Section made. 1:41—Rectal temperature 100°.2.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
1:56 P. M.	64°.22	67°.22	62°.24	.....	540.575
2:12	64.31	67.51			
2:30	64.04	67.51			
2:45	63.92	67.52			
2:56	61.58	67.12	63.032	102°.2	602.672
	60.61 (mean)	67.37 60.61	0.792 (gain)		62.097
		6.76 (gain)			

3 P. M.—Animal breathing quietly, completely paralyzed, but trembling violently all over. The sciatic exposed, and the carotid connected with the cardiometer.

Time.	Arterial Pressure. (Millimetres.)	REMARKS.
3:5 P. M.	90–100	
3:10	115–120	Galvanic current has been applied to the sciatic for half a minute, some not violent reflex contractions, much disturbance of respiration.
3:16	.....	Par vagum cut.
3:21	65–95	Much disturbance of respiration.
3:24	.....	Mild galvanic current applied to the sciatic.
3:26	120–125	Pressure has been steadily rising since the current was applied; there have been no general convulsive movements, but breathing has apparently been affected.
3:35	.....	Animal killed.

Autopsy.—Right half of medulla completely separated exactly at its junction with the pons, excepting a small band upon each side. Left half severed, except a film all across at the lower surface, and a band at the outer edge. No cerebral hemorrhage.

Heat Dissipation.

Before Section.

Quantity of air (V′) = 86.87 at 65°.56—32° = 33.56 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{86.87}{1.0681} = 81.3$. $W = V \times 0.08073 = 6.56$

Rise in temp. of air 6.34 = t. $Q = W \times t \times$ sp. h. $= 6.56 \times 6.34 \times 0.2374 = 9.8735$ = heat given to air.
Rise in temp. of water $0.708 \times 164.1414 = 116.2121$ = heat given to calorimeter.
9.8735 = heat given to air.

Hourly dissipation of heat 126.0856

After Section.

Quantity of air (V′) = 62.097 at 67°.37—32° = 35.37 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{62.097}{1.072} = 57.9$. $W = V \times 0.08073 = 4.67$

Rise in temp. of air 6.76 = t. $Q = W \times t \times$ sp. h. $= 4.67 \times 6.76 \times 0.2374 = 7.4945$ = heat given to air.
Rise in temp. of water $0.792 \times 164.1414 = 130$ = heat given to calorimeter.
7.4945 = heat given to air.

Hourly dissipation of heat 137.4945

Summary.

Hourly dissipation of heat before section 126.0856
Hourly dissipation of heat after section 137.4945

Hourly increase of heat dissipation following section 11.4089

Heat Production.

Before Section.

No change in bodily temperature; hourly dissipation = hourly production of heat 126.0856

After Section.

Rise of bodily temperature in $1\frac{1}{4}$ hours 2°, in 1 hour 1.6 = t. W = 16.75
Q = W × t × sp. h. = 16.75 × 1.6 × 0.75 = 20.1 = heat added to reserve.

Hourly dissipation of heat	137.4945
Hourly addition to heat reserve	20.1
Hourly heat production	157.5945

Summary.

Hourly production of heat after section	157.5945
Hourly production of heat before section	126.0856
Hourly increase of heat production following section	31.5089

Experiment 59.

A mongrel Scotch terrier. Weight 15.75 pounds.

January 3.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:56 P. M	62°.18	64°.06	63°.085	101°.84	28.58
1:11	61.13	64.4			
1:26	61.13	64.18			
1:41	62.66	64.67			
1:56	63.77	65.03	63.319	101.84	97.29
	62.17 (mean)	64.47 62.17	0.234 (gain)	0	68.71
		2.3 (gain)			

2:15 P. M.—Section made, followed at once by seemingly complete paralysis.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
2:43 P. M.	64°.4	65°.84	62°.6	100°.5	107.5
2:58	61.63	64.4			
3:13	61.63	64.76			
3:28	61.43	65.12			
3:43	63.5	65.39	63.104	101.84	180.45
	62.52 (mean)	65.1 62.52	0.504 (gain)	1.34 (gain)	72.95
		2.58 (gain)			

Dog has been howling faintly in the box; shows evidences of sensibility in the body, and can move hind legs slightly, although it is somewhat uncertain whether this is really the case, or whether the movements are reflex; some general tremors; head drawn forcibly to one side; respiration normal.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
4:37 P. M.	63°.23	66°.47	61°.61	101°.84	234.27
4:52	62.6	64.46			
5:7	62.14	64.1			
5:22	62.72	64.28			
5:37	62.72	64.46	62.24	103.1	306.92
	62.68 (mean)	64.75 62.68	0.63 (gain)	1.26 (gain)	72.65
		2.07 (gain)			

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Trmp. (Fah.)	Gen. Meter. (cub. ft.)
8:56 P. M.	68°.81	69°.75	60°.98	102°.56	446.165
9:13	68	68.96			
9:28	67.46	68.45			
9:43	67.46	69.26			
9:58	67.64	68.45	61.98	101.84	521.56
	67.87 (mean)	68.97	1 (gain)	0.72 (loss)	75.395
		67.87			
		1.1 (gain)			

January 4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:25 P. M.	65°.57	67°.79	63°.05	102°.56	541.8
12:40	65.96	67.69			
12:55	67.04	69.17			
1:10	.....	.....	63.725	102.92	576.
	66.19 (mean)	68.22	0.675 (gain)	0.36 (gain)	34.2
		66.19			
		2.03 (gain)			

1:30 P. M.—Dog is conscious, with dulled but not destroyed sensibility in the body, and excessive hyperæsthesia of the head and upper neck, howling violently when these parts are touched. He can kick with all of his legs, but is unable to move his body. He was placed on the table, the thermometer introduced through an opening in the linea alba into the peritoneal cavity, and the sciatic exposed. The galvanic current employed was the full power of a Du Bois Reymond coil, with one large LeClanche cell.

Time. M. Sec.	Temperature.	Irritation of Sciatic.
0	104°.4 F.	
0:30	.....	Commenced.
1	104.5	
1:30	104.4	
2	104.3	
2:15	104.2	
2:45	104	
3:45	103.9	
4:15	103.8	Ceased.
5:15	103.8	
6:42	103.7	
9:45	103.7	
10:30	103.7	

Autopsy.—Section traversing entirely the medulla from side to side on its upper surface on a line with its junction with the pons, reaching half-way through, but leaving the lower part intact.

Heat Dissipation.

Before Section.

Quantity of air (V′) = 68.71 at 64°.47—32° = 32.47 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{68.71}{1.066} = 64.4$. $W = V \times 0.08073 = 5.2$

Rise in temp. of air 2.3 = t. $Q = W \times t \times$ sp. h. $= 5.2 \times 2.3 \times 0.2374 = 2.8393$ = heat units given to air.

Rise in temp. of water $0.234 \times 164.1414 = 38.4091$ = heat given to calorimeter.

2.8393 = heat given to air.

Total dissipation of heat in an hour 41.2484

After Section.

1st Period—

Quantity of air (V′) = 72.95 at 65°.1—32° = 33.1 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{72.95}{1.067} = 68.37$. $W = V \times 0.08073 = 5.5$

Rise in temp. of air 2.58 = t. $Q = W \times t \times$ sp. h. = $5.5 \times 2.58 \times 0.2374 = 3.3686$ = heat given to air.

Rise in temp. of water $0.504 \times 164.1414 = 82.7273$ = heat given to calorimeter.

3.3686 = heat given to air.

Hourly dissipation of heat 86.0959

2d Period—

Quantity of air (V′) = 72.65 at 64°.75—32° = 32.75 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{72.65}{1.067} = 68.09$. $W = V \times 0.08073 = 5.5$

Rise in temp. of air 2.07 = t. $Q = W \times t \times$ sp. h. = $5.5 \times 2.07 \times 0.2374 = 2.7028$ = heat given to air.

Rise in temp. of water $0.63 \times 164.1414 = 103.4091$ = heat given to calorimeter.

2.7028 = heat given to air.

Heat dissipated in one hour 106.1119

3d Period—

Quantity of air (V′) = 75.395 at 68°.97 — 32° = 36.97 = t′.

$V + (V \times t \times 0.002035) = V'$. $V = \frac{75.395}{1.075} = 70$. $W = V \times 0.08073 = 5.7$

Rise in temp. of air 1.1 = t. $Q = W \times t \times$ sp. h. = $5.7 \times 1.1 \times 0.2374 = 1.4885$ = heat given to air.

Rise in temp. of water $1 \times 164.1414 = 164.1414$ = heat given to calorimeter.

1.4885 = heat given to air.

Hourly dissipation of heat 165.6299

4th Period—

Quantity of air (V′) = 34.2 at 68°.22 — 32° = 36.22 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{34.2}{1.073} = 32$. $W = V \times 0.08073 = 2.6$

Rise in temp. of air 2.03 = t. $Q = W \times t \times$ sp. h. = $2.6 \times 2.03 \times 0.2374 = 1.2529$ = heat given to air.

Rise in temp. of water $0.675 \times 164.1414 = 110.7954$ = heat given to calorimeter

1.2529 = heat given to air.

112.0483 = heat dissipated in three-quarters of an hour.

Hourly dissipation of heat 149.3977

Summary.

Hourly heat dissipation before section		41.2484
Hourly heat dissipation after section:	1st period	86.0959
	2d period	106.1119
	3d period	165.6299
	4th period	149.3977

Heat Production.

Before Section.

No change in the bodily temperature.

Hourly dissipation = hourly production of heat 41.2484

After Section.

1st Period—

Rise of the bodily temperature 1.34 = t.

$Q = W \times t \times$ sp. h. = $15.75 \times 1.34 \times 0.75 = 15.8286$ = heat added to reserve.

Hourly dissipation of heat	86.0959
Hourly addition to heat reserve	15.8286
Hourly production of heat	101.9245

2d Period—

Rise in animal temperature 1.26 = t.

Q = W × t × sp. h. = 15.75 × 1.26 × 0.75 = 14.8837 = heat added to reserve.

Hourly dissipation of heat	106.1119
Hourly addition to heat reserve	14.8837
Hourly production of heat	120.9956

3d Period—

Fall of animal temperature 0.72 = t.

Q = W × t × sp. h. = 15.75 × 0.72 × 0.75 = 8.505 = hourly loss from heat reserve.

Hourly dissipation of heat	165.6299
Hourly loss from heat reserve	8.505
Hourly production of heat	157.1249

4th Period—

Rise of animal temperature in three-quarters of an hour 0.36, in one hour 0.48 = t.

Q = W × t × sp. h. = 15.75 × 0.48 × 0.75 = 5.67 = heat added to reserve.

Hourly dissipation of heat	149.3977
Hourly addition to heat reserve	5.67
Hourly production of heat	155.0677

SUMMARY.

Hourly production of heat before section		41.2484
Hourly production of heat after section :	1st period	101.9245
	2d period	120.9956
	3d period	157.1249
	4th period	155.0677

In studying these experiments it is convenient to examine, first, the question of heat dissipation; secondly, that of heat production. The loss of bodily heat was increased by section in Experiments 56, 57, 58, 59. In regard to heat dissipation, section of the higher medulla therefore yields results similar to those caused by division of the spinal cord. In regard to heat production the case is different; it is remarkably diminished by section of the cord, but in all the experiments just detailed it was augmented. Thus in Experiment 56 the increase was about 27 per cent., in Experiment 57 about 67 per cent., in Experiment 58 about 12 per cent. In Experiment 59, which extended over two days with five distinct measurements, the increase at the different successive periods was respectively 77, 200, 300, 270 per cent. The reasons that in some instances the proportionate rise of heat production was much greater than in others are to be in part looked for in the imperfection of the section and in the effects of shock, or of slight bleeding, upon the vaso-motor centres. A point very worthy of notice is, that in several of these experiments no marked rise of the bodily temperature followed the section, the increase of heat dissipation being sufficient to counterbalance the increased production. It would seem, therefore, that the apparently exceptional cases, in which separation of the medulla from the pons without injury to the vaso-motor centres in the floor of the fourth ventricle is not followed by a rise of the bodily temperature, are not to be considered as really exceptional but only as instances in which heat dissipation is increased proportionately to or faster than heat production, so that no accumulation of heat in the body, *i. e.*, no rise of the bodily temperature occurs.

The results of our whole study as to the effects of separation of the medulla from the pons upon thermogenesis may be formulated as follows: *Section of the medulla at its junction with the pons is followed by increased heat dissipation and increased heat production, the increased dissipation usually not keeping pace with the increased production, so that the bodily temperature rises.*

The question which naturally arises at this stage of our investigation is as to the cause of the phenomena which follow superior medullary section. In regard to the heat dissipation, it is apparently simply the result of the increased heat production, a warmer body naturally giving off more heat than a cooler one. More than this, the vaso-motor system being intact, *i. e.*, the normal mechanism for cooling the body being preserved, it is inevitable that the living animal organism, which is producing heat more rapidly than normal, should endeavor to cool its body as rapidly as possible so as to get rid of the excess of heat.

Increased heat production being then the cause of the increased heat dissipation, the problem presents itself—what is the cause of the increased heat production?

Various explanations have been offered to account for the rise of bodily temperature which follows the separation of the medulla from the pons. One set of investigators believe that it is due to irritation of the vaso-motor centres. It is, however, a general guiding principle in making deductions that section of a nerve induces abolition of function and that the symptoms which follow such section are paralytic unless clearly proved to be of other nature. Heidenhain, who has especially advocated the irritation theory, states that he was led to his conclusion by noting that the rabbits, upon which Bruck and Günter experimented, showed symptoms of irritation of the medulla in that their breathing was exceedingly rapid. Acting upon this, he suggested that the effect of puncture should be tried, and accordingly Bruck and Günter instituted such experiments. (*Pflüger's Archiv*, Bd. iii. p. 579.) The temperature rose more uniformly than in the previous experiments in which section was practised. It was found that two or more punctures were more effectual than a single one, and that the effect was still more pronounced, if two of the lance-shaped needles were plunged in at once, and allowed to remain. (Am sichersten darf man auf die Temperatur-Steigerung rechnen, wenn man zwei Nadeln in einer Ebene, die ungefähr 1 mm. vor dem tuberculum interparietale liegt, jederseits 2 mm. von der Median-Ebene in das Gehirn senkt und dieselben liegen lässt.)

It is evident that in the experiment of Bruck and Günter, the nerve centres were actually wounded, and I see no reason for disbelieving the possibility of this wound affecting the conducting power of the nerve fibres, especially as it is plain that the deeper and larger the wound, *i. e.*, the more numerous the needles, the greater was the rise in temperature. The paralytic effect of plunging a lance-shaped needle into a nerve centre certainly reaches, at least for a time, beyond the obvious wound, and the effect of leaving a needle in must be to increase this paralysis by pressure. The reason the rise was obtained more frequently after the puncture than after the section of the medulla, seems to me to depend upon the circumstance that in the former case the vaso-motor centres were not so apt to be involved as in the latter. (See page 61.)

The experiments of Bruck and Günter do not prove then what has been claimed for them. On the other hand, in the numerous experiments which I have made I have very rarely seen any symptom of irritation other than the rise of temperature produced by the section. On the other hand, I have seen the rise of temperature occur when the shock to the respiratory centres has been so great as to paralyze them and suspend breathing. How could the section under these circumstances stimulate the vaso-motor centres which lie so close to the respiratory centre. Again, I have seen the rise of temperature persist for more than twenty-four hours, and have never seen it, when once established, subside so long as the animal survived, unless by the formation of a clot the vaso-motor centre of the medulla was paralyzed. Such is not the history of irritation. I have so often seen this persistent rise of temperature with no signs of irritation, with no apparent disturbance of the circulation or respiration, that I am strongly inclined to believe it to be paralytic in its origin, due to the removal of some force.

Reasoning from rise of temperature in the present case is, for obvious reasons, uncertain in its results, but an examination of the calorimetrical experiments will I believe disprove the correctness of the irritation theory. Taking up the experiments of the last series *seriatim*, it will be seen that in Experiment 56, so far as can be judged from the blood pressure, no vaso-motor spasm existed, the pressure was not high, and galvanization of a nerve increased it nearly one-third by inducing a vaso-motor spasm. Such a rise could hardly have occurred if great vaso-motor irritation, with genuine vaso-motor spasm, had existed before the galvanization of the sciatic. In Experiment 57 there was nothing especially bearing upon the subject under discussion. The same may be said of Experiment 58. Experiment 59, however, furnishes very conclusive evidence. Irritation produced by a section must be greatest immediately after section, and would be expected to disappear in a few hours. Yet in this case the effect upon heat production steadily increased for some hours, and was *much more decided nearly twenty-four hours* after section than it was in the *hour immediately following* section. Thus before the operation, the hourly yield was 41.2484; after the operation, the first hour it was 101.9245; the third hour it was 120.9956; the seventh hour it was 157.1249; and the twenty-third hour, although the dog had been without food and was much exhausted, it was 155.0677. This one experiment is itself sufficient to throw grave doubt upon the irritation theory. As I have in this paper given all the experiments as they were performed, I here append the following, which at first seemed contradictory in its results to those previously performed, but in which the autopsy proved that the medulla was not severed. The chief value of the experiment is in showing that wounds of the cerebellum have little effect on the thermic functions of the body.

Experiment 60.

A large long-haired Pomeranian dog. Weight 24 lbs.

January 9.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)
2:6 P. M.	66°.92	65°.03	59°.1	.....	.....
2:20	67.46	64.31	.....	102°.56	5.63
2:35	67.55	64.22			
2:45	67.73	64.58			
2:6	63.23	64.76	60.3	104	78.3
	66.58	64.58	1.2	1.44	72.67
	64.58	(mean)	(gain)	(gain)	
	2 (loss)				

Section 3:20 P. M. 3:35 P. M.—Rectal temperature 104°.36.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)
3:47 P. M.	67°.76	61°.57	55°.2	.....	127
4	67.76	62.75			
4:15	67.28	62.75			
4:30	66.8	62.65			
4:47	.....	.....	56.85	100°	213
	67.4	62.43	1.65		86
	62.43	(mean)	(gain)		
	4.97 (loss)				

Consciousness and respiration good. Movement is, however, restricted to kicking in the air; all the feet seemingly moved alike. The animal is perfectly powerless to move his body.

January 10. 11:44 A. M.—Rectal temperature 106°.16. Dog has been lying by a hot stove.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)
11:59 A. M.	75°.11	69°.64	61°.5	.....	236.2
12:14 P. M.	69.44	66.8			
12:29	68.24	66.8			
12:50	66.47	66.29			
12:59	.....	.....	62.7	104°.36	324
	69.81	67.38	1.2		87.8
	67.38	(mean)	(gain)		
	2.43 (loss)				

2 P. M.—Dog can get up upon all four legs; holds them wide apart; if he stands he sways to and fro an instant, and then tumbles over; sits most of the time on his haunches, but moves occasionally all about the room; can wag his tail.

Autopsy.—Middle cerebellum cut clear across at its lower portion, entirely through the roof of the fourth ventricle. Medulla not wounded. Pons with a punctured wound on its right side a line in breadth and extending half through.

Heat Dissipation.

Before Section.

Quantity of air 72.67 at 64°.58 — 32° = 32.58.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{72.67}{1.066} = 68.2$. $W \times 0.08073 = 5.5$

Fall in temp. of air 2. $Q = W \times t \times$ sp. h. $= 5.5 \times 2 \times 0.2374 = 2.6114$ = heat taken from air.

Rise in temp. of water $1.2 \times 164.1414 = 196.9697$ = heat given to calorimeter.

2.6114 = heat taken from air.

Hourly dissipation of heat 194.3583

AFTER SECTION.

1st Period—

Quantity of air (V′) = 86 at 62°.43 — 32° = 30.43 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{86}{1.062} = 81$. $W = V \times 0.08073 = 6.54$

Fall in temp. of air 4.97 = t. $Q = W \times t \times$ sp. h. $= 6.54 \times 4.97 \times 0.2374 = 7.7164$ = heat taken from air.

Rise in temp. of water $1.65 \times 164.1414 = 270.8333$ = heat given to calorimeter.

7.7164 = heat taken from air.

Hourly dissipation of heat 263.1169

2d Period—

Quantity of air (V′) = 87.8 at 67°.38 — 32° = 35.38 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{87.8}{1.072} = 82$. $W = V \times 0.08073 = 6.6$

Fall in temp. of air 2.43 = t. $Q = W \times t \times$ sp. h. $= 6.6 \times 2.43 \times 0.2374 = 3.8074$ = heat taken from air.

Rise in temp. of water $1.2 \times 164.1414 = 196.9697$ = heat given to calorimeter.

3.8074 = heat taken from air.

Hourly dissipation of heat 193.1623

SUMMARY.

Before section, hourly dissipation of heat		194.3583
After section, hourly dissipation of heat.	1st period	263.1169
	2d period	193.1623

Heat Production.

BEFORE SECTION.

Hourly rise of animal temperature 1.44 = t.

$Q = W \times t \times$ sp. h. $= 24 \times 1.44 \times 0.75 = 25.92$ = gain of heat reserve.

Hourly dissipation of heat	194.3583
Hourly gain of heat reserve	25.92
Hourly heat production	220.2783

AFTER SECTION.

1st Period—

Fall of animal temperature in $1\frac{1}{4}$ hours 4.36, in one hour 3.49 = t.

$Q = W \times t \times$ sp. h. $= 24 \times 3.49 \times 0.75 = 62.82$ = heat lost from reserve.

Hourly dissipation of heat	263.1169
Hourly loss from heat reserve	62.82
Hourly heat production	200.2969

2d Period—

Fall of animal temperature in $1\frac{1}{4}$ hours 1.8, in 1 hour 1.44 = t.

$Q = W \times t \times$ sp. h. $= 24 \times 1.44 \times 0.75 = 25.92$ = heat lost from reserve.

Hourly dissipation of heat	193.1623
Hourly loss of heat from reserve	25.92
Hourly production of animal heat	167.2423

SUMMARY.

Hourly production of heat before section		220.2783
Hourly production of heat after section:	1st period	200.2969
	2d period	167.2423

If nerve fibres, whose paralysis is either directly or indirectly capable of acting upon the bodily temperature, pass down the medulla, it would, *a priori*, be probable

that by slight wounds we should be able to irritate them, and cause a lessening of the heat prod tion. It is plain that if this can be done the irritation theory must be abandoned. It would be the height of absurdity to maintain any other than a paralytic theory, when complete section destroys and slight wounds or irritation increase a function. In Experiment 60 a slight wound of the pons was followed by an immediate slight reduction of the hourly heat production, but I do not desire to attach too much importance to this, and have performed the following experiments:—

Experiment 61.

A dog, weight 21.5 pounds.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:9 P. M.	67°.64	70°.16	64°.28	101°.84	179.52
12:24	65.84	69 84			
12:39	64.88	67.9			
12:54	65	66.92			
1:9	.....	.....	64.94	102.20	254.095
	65.84 (mean)	68.7 65.84	0.66 (gain)	0.36 (gain)	74.575
		2.86 (gain)			

1:20 P. M.—Puncture made in the medulla; 1:25 P. M. animal can move the front legs, but the hind legs seem to be paralyzed; conscious. 1:31 P. M.—Rectal temperature 103°.64.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
1:46 P. M.	68°.45	69°.94	65°.39	.....	291.55
2:1	68.81	70.34			
2:16	68.72	70.9			
2:31	68.9	69.85			
2:46	68.81	69.85	66.20	100°.76	369.51
	68.74 (mean)	70.18 68.74	0.81 (gain)		77.96
		1.44 (gain)			

Animal has recovered the power of moving the hind legs.

Autopsy.—Only wound of the brain, a minute puncture in the upper surface of the medulla, just in its centre and at the end of the fourth ventricle. Considerable effused blood about the medulla.

Heat Dissipation.

Before Puncture.

Quantity of air (V′) = 74.575 at 68°.7—32° = 36.7 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{74.575}{1.075} = 69.37$. $W = V \times 0.08073 = 5.6$

Rise in temp. of air 2.86 = t. $Q = W \times t \times$ sp. h. $= 5.6 \times 2.86 \times 0.2374 = 3.8022$ = heat given to air.

Rise in temp. of water $0.66 \times 164.1414 = 108.3333$ = heat given to calorimeter.

3.8022 = heat given to air.

Hourly dissipation of heat 112.1355

AFTER PUNCTURE.

Quantity of air (V′) = 77.96 at 70°.18 — 32° = 38.18 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{77.96}{1.078} = 72.3$. $W = V \times 0.08073 = 5.84$

Rise in temp. of air 1.44 = t. $Q = W \times t \times$ sp. h. $= 5.84 \times 1.44 \times 0.2374 = 1.9964$ = heat given to air.

Rise in temp. of water $0.81 \times 164.1414 = 132.9545$ = heat given to calorimeter.

1.9964 = heat given to air.

Hourly dissipation of heat 134.9509

Heat Production.

BEFORE SECTION.

Rise of animal temperature 0.36 = t.

$Q = W \times t \times$ sp. h. $= 21.5 \times 0.36 \times 0.75 = 5.805$ = heat added to reserve.

Hourly dissipation of heat	112.1355
Hourly gain of heat reserve	5.805
Hourly production of heat	117.9405

AFTER SECTION.

Fall of animal temperature in $1\frac{1}{4}$ hours 2.88, in 1 hour 2.304 = t.

$Q = W \times t \times$ sp. h. $= 21.5 \times 2.304 \times 0.75 = 37.152$ = heat lost from reserve.

Hourly dissipation of heat	134.9509
Hourly loss from heat reserve	37.152
Hourly production of heat	97.7989

SUMMARY.

Hourly production of heat before puncture	117.9405
Hourly production of heat after puncture	97.7989
Diminution of heat production following puncture	20.1416

EXPERIMENT 62.

A Scotch terrier, weight 18.5 pounds.

January 7.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:55 P. M.	55°	59°.45	59°.24	102°.92	639
2:16	55.2	59.18			
2:25	56	59.63			
2:40	56.4	59.95			
2:55	58.8	60.44	60.36	102.2	719.29
	56.28 (mean)	59.73	1.12 (gain)	0.72 (loss)	80.29
		56.28			
		3.45 (gain)			

3:15 P. M.—Section made; 3:20 P. M. dog has some power of motion, kicking legs in air.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:37 P. M.	57°.4	60°.16	60°.1	101°.84	734
3:52	55.1	60.13			
4:7	56	60.56			
4:22	55.8	60.23			
4:37	57.5	60.33	60.68	99.24	797.25
	56.36 (mean)	60.28	0.58 (gain)	2.6 (loss)	63.25
		56.36			
		3.92 (gain)			

January 8.—Dog has violent rolling movements, apparently the result of voluntary efforts—they are always from left to right—body rolling over and over. Left side apparently as powerful as ever; right side very decidedly paralyzed, but dog can still move legs feebly, sensibility also very dull. Left side hyperæsthetic. Right eye anæsthetic; inflammatory changes have commenced in the cornea. Consciousness and respiration perfect.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
1:33 P. M.	62°.24	63°.41	61°.52	102°.92	852
1:45	61.4	63.32			
2:10	61.8	63.68			
2:25	61.7	63.68			
2:33	63.23	64.04	62.36	102.92	922
	62.08 (mean)	63.63 62.08	0.84 (gain)	0	70
		1.55 (gain)			

3 P. M.—Dog killed.

Autopsy.—Large wound of cerebellum. Medulla only wounded in the outer third of the right side on the line of its junction with the pons: here it is divided.

Heat Dissipation.

Before Section.

Quantity of air (V′) = 80.29 at 59°.73—32° = 27.73 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{80.29}{1.056} = 76$. $W = V \times 0.08073 = 6.14$

Rise in temp. of air 3.45 = t. $Q = W \times t \times$ sp. h. $= 6.14 \times 3.45 \times 0.2374 = 5.0288$ = heat given to air.

Rise in temp. of water $1.12 \times 164.1414 = 183.8384$ = heat given to calorimeter.

5.0288 = heat given to air.

Hourly dissipation of heat 188.8672

After Section.

1*st Period*—

Quantity of air (V′) = 63.25 at 60°.28—32° = 28.28 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{63.25}{1.058}$ 59.8. $W = V \times 0.08073 = 4.8$

Rise in temp. of air 39.2 = t. $Q = W \times t \times$ sp. h. $= 4.8 \times 3.92 \times 0.2374 = 4.466$ = heat given to air.

Rise in temp. of water $0.58 \times 164.1414 = 95.2020$ = heat given to calorimeter.

4.466 = heat given to air.

Hourly dissipation of heat 99.668

2*d Period*—

Quantity of air (V′) = 70 at 63°.63—32° = 31°.63 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{70}{1.064} = 65.8$. $W = V \times 0.08073 = 5.3$

Rise in temp. of air 1.55 = t. $Q = W \times t \times$ sp. h. $= 5.3 \times 1.55 \times 0.2374 = 1.9502$ = heat given to air.

Rise in temp. of water $0.84 \times 164.1414 = 137.8787$ = heat given to calorimeter.

1.9502 = heat given to air.

Hourly dissipation of heat 139.8289

Summary.

Hourly dissipation of heat before section		188.8672
Hourly dissipation of heat after section:	1st period	99.668
	2d period	139.8289

Heat Production.

BEFORE SECTION.

Fall of animal temperature 0.72 = t.

Q = W × t × sp. h. = 18.5 × 0.72 × 0.75 = 9.99 = heat lost from reserve.

Heat dissipated in one hour	188.8672
Heat lost in one hour from reserve	9.99
Total production of heat in one hour	178.8772

AFTER SECTION.

1*st Period*—

Fall of animal temperature 2.6 = t.

Q = W × t × sp. h. = 18.5 × 2.6 × 0.75 = 36.07 = heat lost from reserve.

Heat dissipated in one hour	99.668
Heat lost in one hour from reserve	36.075
Hourly production of heat	63.593

2*d Period*—

No alteration of animal temperature.

Hourly dissipation and therefore production of heat 139.8289

SUMMARY.

Hourly production of heat before section		178.8772
Hourly production of heat after section :	1st period	63.593
	2d period	139.8289

In the first of these experiments the markedly increased heat dissipation strongly indicates a partial vaso-motor palsy produced by effused blood. It is therefore possible that the diminished heat production had its origin in this cause and not in any irritation of inhibitory nerve fibres. Experiment 61 is a much more decisive one. In it, directly after the wound and at a time when there were very marked symptoms of motor irritation, both heat production and heat dissipation were enormously reduced. It will be remembered that in vaso-motor palsy, heat dissipation is at first increased, so that the fact that the heat dissipation fell from 188.8672 units per hour to 99.668 units per hour proves that there was no vaso-motor palsy. Indeed it would seem that no conceivable vaso-motor condition could account for the symptoms. The wound was a small one situated high up, *i. e.* at a distance from the vaso-motor centre, and could not have caused vaso-motor palsy. Those who hold the irritation theory and explain the *increased* production of heat which is produced by section of the medulla where it joins the pons, cannot invoke the same irritation to account for the extraordinarily *diminished* heat production (from 178.8772 to 63.593 units) caused by the slight wound at the position of section in the other cases. In Experiment 59, after division of the medulla the heat production steadily increased for hours, so that twenty-four hours after division of the medulla the hourly rate was nearly four times what it was before section, although during the first hours of section it was only twice as great as the norm. Mechanical irritation naturally subsides rapidly in its effects, instead of increasing in this way. This is very plainly shown by the experiment last recorded. At first, heat production was lessened about two-thirds by the puncture, but in twenty-four hours it had increased almost to what it was before section—so nearly, indeed, that the difference, amounting only to about one-

fifth, can readily be accounted for by the exhaustion following the injury, and especially by the prolonged deprivation of food. Taking together all the facts which have been heretofore brought forward and apparently proven in this memoir, I can arrive at no other conclusion than that the rise of bodily temperature, and of heat production following separation of the pons from the medulla, is paralytic and due to the removal of some active force.

Tscheschin, led by the rise of the bodily temperature which he had noticed after separation of the medulla from the pons, proposed the theory that there is in the brain, somewhere above the pons, a nerve centre whose function it is directly to inhibit or repress the chemical movements of the body, *i. e.* the production of animal heat, and which has been called the inhibitory heat centre. It must be clearly understood that this theory involves the exercise of a controlling influence of the nervous system upon the nutrition of the body. There are physiologists who deny the possibility of such control. It would seem, however, that such denial is opposed to many well established physiological facts. The performance of function is certainly associated with or dependent upon nutritive changes, and production of contraction in a muscular fibre by nerve force must be by the exertion of a direct influence upon its nutrition.

The influence of the nervous system upon disease, *i. e.* upon perverted nutrition, appears frequently to be a direct one—the disappearance of warts, the subsidence of inflammation, and the cure of chills, under the spells of the so-called magnetic physicians, as well as the success of tractors and of metallotherapy—all bear witness to the same fact. I have personal knowledge of two cases in which milk secreted in a previously healthy woman directly after a severe fright, produced immediately violent convulsions in the child, in one case ending almost at once fatally. Every one must have seen violent chorea produced by sudden emotion. Even the grave nutritive disorder chlorosis seems at times to owe its origin to a similar cause. I have seen a case in which a boy violently throwing a ball felt something yield in the arm, the sensation being followed at once by numbness, and in a few hours by a copious eruption of small herpetic vesicles all over the region of the distribution of the median nerve. The curious phenomena of ordinary herpes zoster, the trophic changes often associated with neuralgia or paralysis of the fifth pair of nerves, the various peripheral changes following spinal diseases cannot be explained upon the idea of a vaso-motor production. Charcot and his pupils have by their labors shed much light upon this subject. It is only necessary to mention their observations on infantile palsy, on acute decubitus, on the changes in the joints in locomotor ataxy, and on amyotrophic paralysis, all of which afford proof of the profound structural alterations which may occur under the influence of spinal disease.

To examine the clinical and pathological evidence upon this point would carry us too far beyond the subject directly in hand to be proper to the occasion. It is only necessary to reiterate the fact that various sorts of nutritive changes—changes of kind as well as of degree of growth—are traceable to disease of the nervous system, and to call attention to the very able paper of M. Landouzy, on this subject, in the *Revue Mensuelle de Médecine et de Chirurgie*, January, 1878.

For reasons just assigned it seems to me that there is no inherent absurdity in the inhibitory heat centre theory. Its correctness is however certainly not proven by any facts as yet adduced. It is probable that the bulk, at least, of the animal heat is developed in the muscles, and it is possible that the so-called general vaso-motor centre of the medulla is only the centre of the abdominal circulation. As is well known, the bloodvessels of the abdomen, if perfectly relaxed, are sufficient to hold almost all the blood of the body. It is conceivable then that they may dominate the arterial pressure; so that a vaso-motor centre for the muscular system may exist higher up in the brain than the medulla, and yet not reveal itself by changes in the arterial pressure, just as the addition of a hundred men to an army of 100,000, or of a gill of water to a hogshead full would not be noticed. If such a muscular centre did exist, section of the medulla at the junction with the pons would quicken the muscular circulation most markedly and might thereby materially increase the amount of heat production.

The determination of the comparative probability of the two theories must be left to a later portion of this paper, after it has been shown that there are high up in the brain certain centres evidently connected in some way with the production of animal heat.

For the present we can only conclude that the rise of bodily temperature following separation of the pons from the cord is due either to paralysis of an inhibitory heat centre or of a muscular vaso-motor centre.

Although the higher centre, whatever its nature may be, which dominates animal heat production is very powerful, it is evident that the thermic activities of the organism must be very greatly affected by the circulation and the respiration: that cutting off the materials of growth and the oxygen required for the life processes must exercise a dominant influence, and that an increased supply of these agents must also produce a decisive effect. The following experiment is of interest as showing the very great power of defective respiration in preventing the increased heat production which otherwise would have followed the operation performed.

Experiment 63.

A dog Weight about 30 lbs

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (cub. ft.)	Air Calcium Tube. (cub. ft.)
12:16 P. M.	80°.88	81°.68	79°.8	102°.2	925.44	21.21835	02.9418	133.9062	126.23
12:31	80.5	81.9							
12:46	80.86	82.04							
1:1	81.22	82.04	80.52	102.2	995.218	21.2495	02.9868	133.93275	126.2505
	80.86	81.91	0.72	0	69.778	0.03115	0.045	0.02655	0.0205
	(mean)	80.86	(gain)		0.03115				
		1.05			69.80915				
		(gain)							

1:45 P. M.—Section made. Respiration at once ceased. Artificial respiration was kept up about half an hour, when imperfect respiration came on. From the beginning the temperature of the rectum rose slowly and steadily. At 3 P. M. respiration very slow, only four a minute; lips, etc., cyanotic. Rectal temperature 106°.7 F.

Time.	Air Temp.	Tube Temp.	Box Temp.	Rect. Temp.	General Meter.	Sample Meter.	Air Meter.	Sample Calcium Tube.	Air Calcium Tube.
	(Fah.)	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(cub ft.)
3:18 P. M.	84°.7	83°.7	82°.56	106°.7	171.225	21.3493	2.9858	133.92375	126.2305
3:23	84.35	83.95							
3:38	84.15	82.04	82.76	105.8	204.839	21.3916	3.0651	133.95702	126.25745
	84.4	83.23	0.2	0.9	33.614	0.0423	0.0793	0.03327	0.02695
	83.23	(mean)	(gain)	(loss)	0.0423				
	1.17 (loss)				33.6563				

Animal just alive when taken out of box, breathing as before, and very cyanotic; killed.
Autopsy.—Complete section of the medulla at the border of the pons. Brain nearly free from clots.

Heat Dissipation.

Before Section.

Quantity of air (V′) = 69.80915 at 81°.91 — 32° = 49.91 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{69.80915}{1.1016} = 63.3$. $W = V \times 0.08073 = 63.4 \times 0.08973 = 5.1$

Rise in temp. of air 1.05 = t. $Q = W \times t \times$ sp. h. $= 5.1 \times 19.5 \times 0.2374 = 1.2713$
Rise in temp. of water $0.72 \times 164.1414 = 118.1818$ = heat given to calorimeter.
Quotient for box $2241 \times 0.02655 = 59.4985$ = moisture leaving box.
Quotient for air $1551.3 \times 0.0205 = 31.8016$ = moisture entering box.

27.6969 = moisture vaporized in box.

$\frac{27.6969}{6.2789} = 4.4111$ heat expended in vaporization.

1.2713 = heat given to air.
4.4111 = heat expended in vaporization
118.1818 = heat given to water.

Hourly dissipation of heat 123.8642

After Section.

Quantity of air (V) = 33.6563 at 83°.23 — 32° = 51.23 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{33.6563}{1.104} = 30.5$. $W = V \times 0.08073 = 2.46$.

Fall in temp. of air 1.17 = t. $Q = W \times t \times$ sp. h. $= 2.46 \times 1.17 \times 0.2374 = 0.6832$ = heat taken from air.
Rise in temp. of water $0.2 \times 164.1414 = 32.8283$ = heat given to water.
Quotient for box $795 \times 0.03327 = 26.4496$ = moisture leaving box.
Quotient for air $425 \times 0.02695 = 11.4537$ = moisture entering box.

14.9959 = moisture vaporized in box.

$\frac{14.9959}{6.2789} = 2.3883$ = heat expended in vaporization.

32.8283 = heat given to water.
2.3883 = heat expended in vaporization.
34.2166
0.6832 = heat taken from air.
33.5334 = total dissipation of heat in half an hour.

Hourly dissipation of heat 67.0668

Summary.

Hourly dissipation of heat before section	123.8642
Hourly dissipation of heat after section	67.0668
Decrease in hourly dissipation of heat	56.7974

Heat Production.

BEFORE SECTION.

No determination of reserve heat.
Heat dissipation, = heat production 123.8642

AFTER SECTION.

Fall of animal temperature 0.9 = t. W = 30.
Q = W × t × sp. h. = 30 × 0.9 × 0.75 = 20.25 = lessened amount of reserved heat.

Heat dissipation	67.0626
Heat drawn from reserve	20.25
Hourly production of heat	46.8126

SUMMARY.

Hourly production of heat before section	123.8642
Hourly production of heat after section	46.8126
Hourly decrease in production of heat	77.0516

In looking over the summary of this experiment it will be seen that, although there was section of the medulla at its junction with the pons, yet the hourly rate of heat production was decreased from 123.8642 units to 46.8126 units. This extraordinary result is readily accounted for by the state of the respiration. The rate of the breathing was reduced to four or five acts per minute, and the intensely cyanotic lips and mouth of the unconscious animal showed the lack of oxygen. This experiment is of further interest on account of the great and rapid rise of the bodily temperature which followed the operation notwithstanding the diminished heat production. It affords a striking example of the fact that the temperature register is no index of the amount of heat production. It is also important as indicating that retention of heat follows vaso-motor spasm. Vaso-motor spasm, it is well known, is one of the phenomena of asphyxia, and must have been highly developed when the first rise of temperature occurred. That excessive heat retention was the cause of the rise of temperature is very evident, and is also directly proven. As the stimulation lasted and the relaxation of fatigue began to be developed, the temperature began to fall, but even at this time heat dissipation was at an hourly rate of 67.0626 instead of 123.8642. The difference of course had much of its causation in the diminished heat production; yet if the avenues of escape had been open, the bodily temperature would have rapidly fallen to below the normal point instead of remaining as it did over 3.5 degrees above normal. How the results of this experiment could be explained by, or indeed made concordant with, the irritation theory it is hard to understand. That the vaso-motor as well as the respiratory system largely dominates heat production is abundantly shown by my experiments upon the cord. After section of the cord there is of course paralysis of the fibres which are cut when the medulla is separated from the pons. This is however more than counterbalanced by the vaso-motor palsy, for diminished heat production is always the result of cord section.

The fact that the production of animal heat is influenced by some centres situated in or above the pons Varolii, and also that it is in some degree independent of

changes in the general arterial pressure, is corroborated by the results of irritation of a peripheral nerve.

In 1870, P. Heidenhain announced (*Pflüger's Archiv*, p. 504) that when a sensitive nerve is stimulated, a fall of temperature occurs simultaneously with the rise of the blood pressure. I shall not attempt to follow this memoir closely, but shall simply state the results of experiments, the conclusions drawn, and the evident reasons there are for not allowing the justice of the deductions made.

The experimental facts which were reached are as follows:—

1st. Irritation of a sensitive nerve causes a rise in blood pressure but a fall in temperature.

2d. This fall occurs in the posterior part of the body even after the circulation has been cut off by forcible compression of the aorta.

3d. When, in animals which have been thrown into a high fever by the injection of putrid matters, a sensitive nerve is stimulated, a rise of blood pressure occurs as in the normal condition, but *no change of temperature.*

Dr. Heidenhain believes that when the blood pressure rises the blood current moves more rapidly, and that the fall of temperature is due to the surface blood being returned more quickly to the internal organs and thereby cooling them more rapidly than normal. It seems scarcely necessary to point out that if the blood is returned more rapidly to the interior, it of necessity remains upon the exterior for a shorter period, and is cooled less than normal. It makes no difference whether a quart of fluid cooled one-tenth of a degree, or a pint cooled two-tenths of a degree is returned in a given time so far as the general temperature is concerned. Moreover it has been distinctly proven in an earlier part of this memoir, that vaso-motor paralysis, not spasm, favors rapid dissipation of heat. Either the second or the third of Heidenhain's asserted experimental facts seems, to my mind, entirely sufficient to prove the incorrectness of his theory; for if the fall of temperature occurs in a part which is deprived of its blood, or if it does not occur in fever although the nerve irritation has its usual effect upon the blood pressure, how can alterations in the blood pressure be the cause of the fall? The improbability of Heidenhain's theory is further shown by the circumstance that in some of his experiments the temperature fell steadily after galvanization of a nerve though the animals were wrapped in wool. On the whole, the proof appears to be very strong that the fall of temperature which follows galvanization of a sensitive nerve is not due to an increased dissipation of heat from the body owing to changes in the circulation.

The work of Heidenhain has been reviewed and extended by Dr. F. Riegel (*Pflüger's Archiv*, 1871, Bd. iv.), who found that the fall of temperature did not always occur when the nerve was irritated, although the blood pressure always rose, and also that the temperature usually remained at the minimum point for a long time after the withdrawal of the stimulus, although the blood pressure returned at once to the normal point.

The experiments and results of Heidenhain were, indeed, not entirely novel. The same ground appears to have been covered by Mantigazza. Where his memoir

is published I am unable to say, but his results and conclusions, as quoted without reference, by Redard (*Archives Générales*, 6e Série, t. xix. p. 35), are as follows:—

1. Intense pain transmitted by spinal nerves and the skin causes a rapid fall of temperature, which in the rabbit amounts to from 0°.68 C. to 2°.48 C.; the mean being 1°.27 C. (= 2°.29 F.)

2. The temperature falls perceptibly during the first minute, and arrives at its maximum in from ten to twelve minutes.

3. The lowered temperature may last for an hour and a half.

4. The fall is most marked when the pain does not give origin to muscular spasms.

5. The same phenomena occur in man.

6. The grave abatement of temperature produced by a pain lasting ten minutes would appear to be dependent upon an alteration of the chemical actions of the body, and not merely to an indirect influence exerted upon the vaso-motor nerves.

In order to clearly determine the truth concerning the influence of irritation upon a sensitive nerve, I have performed a number of experiments, some of which are repetitions of those of earlier observers. The records of these experiments are as follows:—

Experiment 64.

A young pup. Crural and axillary nerves exposed, and thermometer placed in peritoneal cavity.

Min. Sec.	Temp.	REMARKS.
0	101°.25 F.	Intense current to the brachial plexus; violent cries and struggles.
1:30	101.5	
2:30	100.75	Current withdrawn.
4	100.75	
4:30	100.62	
5:30	100.5	
7	100.37	
9	100.37	Current reapplied.
10	100.37	
11	100.25	Current broken.
13	100.12	
17	100	
19	99.83	
21	99.75	
22	99.61	
24	99.5	Current reapplied.
25	99.5	
26	99.5	
27	99.37	Current broken.
29	99.25	
67	99	
97	100	
127	100	Animal killed.

Experiment 65.

A stout tomcat. The animal was closely wrapped up in flannels, many folds around the body and legs. Thermometer in the peritoneal cavity.

Min. Sec.	Temp.	REMARKS.
0	101°.61 F.	
5	101.5	Brachial nerves cut down upon and exposed since last note.
6	.....	Intense current applied to the nerves.
7	101.37	Violent cries and struggles.
8	101.5	Current interrupted.
20	101.61	
25	101.5	
26	.....	Current applied.
26:30	101.87	Violent struggles and cries.
27	101.5	
28	101.67	Current broken.
30	101.5	
33	101.5	
35	101.5	Cat killed.

Experiment 66.

An adult rabbit. Under chloroform the axillary nerves were exposed, and a thermometer inserted through a small opening in the linea alba into the peritoneal cavity.

Min. Sec.	Temp.	REMARKS.
0	102°.75 F.	
2	102.75	Current applied to the nerve; violent struggles and cries.
3:30	102.75	Temperature of room 83°. Current broken.
4:30	102.87	
5	102.61	
7	102.61	
8	102.37	
10	102.37	
13	102.25	
15	102.13	
18	102	
19	101.87	Current applied; struggles and cries as before.
20	102	Current broken.
21	102	
22	101.75	
26	101.61	
29	101.5	
32	101.37	

Experiment 67.

An adult rabbit; prepared as in previous experiments, except that the crural nerve was used.

Min. Sec.	Temp.	REMARKS.
0	103°.25 F.	
2	103.25	Current applied to nerve.
2:30	103.75	Violent struggles and cries; current broken.
4	103.5	
10	102.75	Rabbit quiet.
12	102.5	
14	102.75	
15	102	
17	101.5	

Min. Sec.	Temp.	REMARKS.
21:30	101.25	Anæsthesia has been induced and the opposite crural nerve exposed, which was used throughout the rest of the experiment.
22	101.5	Current applied.
22:30	101.5	Current broken.
23:30	101.62	Rabbit squealing and struggling.
25	101.62	Current applied, giving rise to violent struggles and cries.
26	101.75	Current broken.
27	101.75	
29	101.5	
32	101.13	
35	100.87	
40	100.25	
47	99.62	
49	99.5	Rabbit killed.

An examination of these records will show that rarely did the temperature fall whilst the current was being applied, and that in several cases there was even a perceptible rise, amounting to from an eighth to a half of a degree. This rise I believe to have been due to the rise of blood pressure and to the violent muscular exertion which the pain caused. It certainly occurred at the period at which the blood pressure was increased. In many experiments upon the effects of irritation of a sensitive nerve on the arterial pressure, I have found that if the rise occur it is immediate, and that in a very brief time after the cessation of the irritation the arterial pressure becomes normal. In all of my experiments, here reported, the fall of temperature did not fairly commence until after the period of disturbance of the circulation had passed by; in most cases it was very persistent and progressively increased for many minutes. In Experiment 67 the fall amounted to three degrees and three-quarters, and did not reach its maximum until twenty-three minutes after the last irritation of the sensitive nerve. It is therefore highly improbable that the fall of temperature is due to disturbances of the circulation, since, at the time of the fall of temperature, the circulation is not profoundly affected. The time of the fall and its permanence indicate that *the fall of temperature which results from the irritation of a sensitive nerve, is independent of the state of the circulation as measured by the arterial pressure.*

If this proposition be correct, and if, as has already been rendered probable, there is above the medulla a centre which has the power of directly or indirectly inhibiting heat production, it is reasonable to expect that, after section of the medulla at the border of the pons, galvanization of a sensitive nerve will fail to affect the temperature. Further, if such galvanization does fail to affect the temperature, it is evident that a heat-controlling centre of some kind, situated above the pons, must exist, since the general circulation and respiration are affected as in the normal animal. Such is the reasoning, and in order to test what the fact may be, the following experiments were performed.

Experiment 68.

A stout young dog. Medulla, as demonstrated at autopsy, nearly cut through at its junction with the pons.

Time.	Temp.	REMARKS.
1 P. M.	101°.75 F.	Galvanization of a sensitive nerve with an intense Faradic current for half a minute had no perceptible effect on the bodily temperature. Dog watched many minutes.

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Experiment 69.

A stout terrier. Medulla oblongata found at the autopsy to be very nearly severed from the pons.

Time.	Temp.	Remarks.
2:10 P. M.	107°.75 F.	A very intense Faradic current passed for one minute through the axillary nerves had no influence on the bodily temperature. Animal watched many minutes.

Experiment 70.

A powerful dog. Medulla oblongata separated from the pons, as proven by the autopsy.

Time.	Temp.	Remarks.
1:30 P. M.	105°.25 F.	Galvanization of a large sensitive nerve with a very strong Faradic current for one and a half minutes had no perceptible effect on the temperature. Animal watched many minutes.

Experiment 71.*

A cur. The medulla had been separated from the pons and the temperature had risen to 105°.9.

Min. Sec.	Temp.	Remarks.
1	105°.9	Applied a very powerful Faradic current to the sciatic nerve.
1:45	106	
2	106	
15	106	
30	106	
45	106	
3	106	
15	106	
:15	106	
5:15	106.1	
6	106.2	
7	106.2	Current increased to the whole force of the Du Bois Reymond coil.
8	106.1	
9	106.1	
10	106.1	Current stopped.

Waited 5 minutes, and then reapplied the current with the full force of the Du Bois Reymond coil.

1	106.4	Current applied; full force of the Du Bois Reymond coil.
15	106.2	
1:45	106.2	
2	106.2	
3	106.1	
4	106.2	Current stopped.
5	106.2	
6	106.2	
10	106.2	

The current applied with the full coil was so exceedingly powerful as to produce violent general muscular tetanus.

It will be seen that these experiments are very uniform in their results and very decisive. Every care was practised to have the nerve fresh and uninjured, and the animal watched. In two of the experiments the effect of the current upon the

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* This experiment was performed in the presence of Prof. Harrison Allen and Demonstrators Reichert and Smith, of the Physiological Laboratory of the University of Pennsylvania.

blood pressure was studied and found to be normal. In one experiment, which has been previously reported (see Experiment 59), stimulation of the nerve had a very decided effect upon the bodily temperature; the result is however not contradictory, for, at the autopsy, the section of the medulla was found to be partial; and it is probable that enough of the fibres remained intact to make the powerful stimulation felt.

The results of these experiments are seemingly different from those of similar experiments made by R. Heidenhain (*Pflüger's Archiv*, Bd. iii. p. 510). That observer states that in a number of instances he has found that irritation of a sensitive nerve, after separation of the pons from the medulla, is followed by a fall of temperature. On examining the record of the single detailed experiment, I find, however, that the fall took place solely during the application of the galvanism to the nerve, and amounted at such times only to from 0.05 to 0.1 of a degree C. (0.09 to 0.18 F.). Indeed, throughout the experiment, the temperature really rose, so that at the end it was decidedly higher during the periods of nerve excitement than it was before the nerve had been irritated at all; and at the close, when the nerve was not stimulated, the bodily heat was 0.2 C. (0.36 F.) higher than at first. This very slight fall of temperature, occurring during the period of stimulation, is something very different from the profound fall, that we have been discussing, which occurs some time after the stimulation. This slight, evanescent alteration of temperature—which also occurred in Experiment 71 of my own series between the 7th and 10th minute—is very probably due to alterations in the respiration or circulation. The experiments of Heidenhain, therefore, corroborate rather than contradict those whose records have just been given.

In conclusion the experiments seem to establish the proposition that *galvanization of a sensitive nerve produces a fall of the arterial pressure by acting upon some nervous centre situated either in or above the pons.*

The existence of some centre in or above the pons directly or indirectly controlling heat production having been established, attention naturally directs itself towards the discovery of the seat of that centre. Mechanical destruction of the pons being evidently not practicable without involving other vital portions of the brain, I have tried to accomplish the result by means of caustic injections. The experiments performed are as follows:—

Experiment 72.

A dog. Weight 14 lbs.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)	Remarks.
12:39 P. M.	58°.64	67°.02	66°.2	103°.1	959.1	
12:54	59.04	66.8				
1:9	65.21	67.23				
1:24	65.21	67.23				
1:39	66.29	67.59	66.371	103.1	1045	
	62.88 (mean)	67.17	0.171 (gain)	0	85.9	
		62.88				
		4.29 (gain)				

2 P. M.—Three minims of strong aqua ammoniæ were thrown by means of a hypodermic syringe into the pons. Most violent tetanus was at once developed, and continued about twenty minutes, when breathing recommenced, life having been sustained by artificial respiration. 2:40 P. M.—Dog relaxed. Rectal temperature 99°.32 F.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)	REMARKS.
2:54 P. M.	65°.96	68°.54	68°.27	.....	1076	
3:9	65.66	69.26				Animal in constant motion in the box.
3:24	65.21	69.26				
3:39	68.9	68.72				
3:54	67.46	69.75	68.625	101°.48	1146	
	66.64 (mean)	69.11 66.64	0.355 (gain)		70	
		2.47 (gain)				

4 P. M.—Animal breathing slowly and deeply; relaxed but with fibrillary contractions of the muscles. Died during the evening or night.

Autopsy.—Cerebellum very widely destroyed. Upper one-fourth of the pons disintegrated. Medulla not injured.

Heat Dissipation.

BEFORE INJECTION.

Quantity of air (V′) = 85.9 at 67°.17 — 32° = 35.17 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{85.9}{1.0716} = 80.2$. $W = V \times 0.08073 = 6.47$

Rise in temp. of air 4.29 = t. $Q = W \times t \times$ sp. h. $= 6.47 \times 4.29 \times 0.2374 = 6.5893$ = heat given to air.

Rise in temp. of water $0.171 \times 164.1414 = 28.0682$ = heat given to calorimeter.

6.5893 = heat given to air.

Hourly dissipation of heat 34.6575

AFTER INJECTION.

Quantity of air (V′) = 70 at 69°.11 — 32° = 37.11 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{70}{1.0755} = 65.1$. $W = V \times 0.08073 = 5.25$

Rise in temp. of air 2.47 = t. $Q = W \times t \times$ sp. h. $= 5.25 \times 2.47 \times 0.2374 = 3.0805$ = heat given to air.

Rise in temp. of water $0.355 \times 164.1414 = 58.2702$ = heat given to calorimeter.

3.0805 = heat given to air.

Hourly dissipation of heat 61.3507

SUMMARY.

Hourly dissipation of heat after injection	61.3507
Hourly dissipation of heat before injection	34.6575
Hourly increase of heat following injection	26.6932

Heat Production.

BEFORE INJECTION.

No change in heat reserve.

Hourly dissipation of heat = hourly production 34.6575

AFTER INJECTION.

Rise of animal temp. in $1\frac{1}{4}$ hours 2.16, in 1 hour 1.728 = t.

$Q = W \times t \times$ sp. h. $= 14 \times 1.728 \times 0.75 = 18.144$ = hourly gain of heat reserve.

61.3507 = hourly dissipation of heat.

Hourly production of heat 79.4947

SUMMARY.

Hourly production of heat after injection	79.4947
Hourly production of heat before injection	34.6575
Hourly increase of heat production following injection	44.8372

EXPERIMENT 73.

A dog. Weight 16 lbs.

February 6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:50 A. M.	67°.55	71°.59	70°.07	102°.2	170.65
12:05 P. M.	68.99	70.64			
12:20	68.99	70.64			
12:35	68.81	70.52			
12:50	68.99	70.06	70.358	102.92	253.12
	68.67 (mean)	70.69	0.288 (gain)	0.72 (gain)	82.47
		68.67			
		2.02 (gain)			

1:12 P. M.—Injected five drops of a 20 per cent. solution of chromic acid into the pons.

1:19 P. M.—Rectal temperature 103°.64. Some rigidity of muscles, most marked on the left side. General palsy; sensations blunted.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:41 P. M.	69°.44	71°.84	70°.079	.....	270.4
1:56	68.12	70.43			
2:11	68.12	70.34			
2:26	67.76	70.34			
2:41	67.98	69.96	70.52	.....	351.4
	68.28 (mean)	70.58	0.441 (gain)	.....	81
		68.28			
		2.3 (gain)			

2:5 P. M.—Rectal temperature 101°.23.

February 7. 10:50 A. M.—Dog has been lying by a warm fire. Rectal temperature 102°.56.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:1 A. M.	.....	.....	68°.72	.....	367.15
11:16	65°.48	69°.20			
11:31	65.84	69.17			
12:1 P. M.	65.84	69.17	68.99	.....	441.
	65.72 (mean)	69.18	0.27 (gain)	.....	73.85
		65.72			
		3.46 (gain)			

12:20 P. M.—Sensation seemingly perfect; the dog can kick well with all his legs, but cannot get up on them. Rectal temperature 100°.48. Dog killed.

Autopsy.—Complete destruction of the left cerebellar lobe and peduncle; upper superficial portion of the pons completely destroyed.

Heat Dissipation.

First Period—

Quantity of air (V′) = 82.47 at 70°.69 — 32° = 38.69 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{82.47}{1.079} = 76.4$. $W = V \times 0.08073 = 6.17$.

Rise in temp. of air 2.02 = t. $Q = W \times t \times$ sp. h. $= 6.17 \times 2.02 \times 0.2374 = 2.9588$ = heat given to air.

Rise in temp. of water $0.288 \times 164.1414 = 47.2727$ = heat given to calorimeter.

2.9588 = heat given to air.

Heat dissipated in an hour 50.2315

Second Period—

Quantity of air (V′) = 81 at 70°.58 — 32° = 38.58 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{81}{1.0785} = 75.1$. $W = V \times 0.08073 = 6.06$

Rise in temp. of air 2.3 = t. $Q = W\ t \times$ sp. h. $= 6.06 \times 2.3 \times 0.2374 = 3.3089$ = heat given to air.

Rise in temp. of water $0.441 \times 164.1414 = 72.3864$ = heat given to calorimeter.

3.3089 = heat given to air.

Hourly dissipation of heat 75.6953

Third Period—

Quantity of air (V′) = 73.85 at 69°.18 — 32° = 37.18 = t′.

$V + (V \times t \times 0.002035) = V'$. $V = \frac{73.85}{1.0764} = 68.6$. $W = V \times 0.08073 = 5.54$.

Rise in temp. of air 3.46 = t. $Q = W \times t \times$ sp. h. $= 5.54 \times 3.46 \times 0.2374 = 4.5245$ = heat given to air.

Rise in temp. of water $0.27 \times 164.1414 = 44.3181$ = heat given to calorimeter.

4.5245 = heat given to air.

Hourly dissipation of heat 48.8426

SUMMARY.

Hourly heat dissipation.	First period	50.2315
	Second period	75.6953
	Third period	48.8426
Gain of heat dissipation in second period		25.4638
Loss of heat dissipation in third period		1.3889

Heat Production.

First Period—

Rise of bodily temperature 0.72 = t.

$Q = W \times t \times$ sp. h. $= 16 \times 0.72 \times 0.75 = 8.64$ = heat added to reserve.

50.2315 = dissipation of heat.

Hourly production of heat 58.8715

Second Period—

Fall of bodily temperature in 92 minutes 2.41; in one hour 1.572 = t.

$Q = W \times t \times 0.75 = 16 \times 1.572 \times 0.75 = 18.864$ = heat lost from reserve.

Dissipation of heat	75.6953
Loss from heat reserve	18.864
Hourly production of heat	56.8313

Third Period—

Fall of bodily temperature in 90 minutes 2.08; in one hour 1.3867 = t.

$Q = W \times t \times$ sp. h. $= 16 \times 1.3867 \times 0.75 = 16.6404$ = loss from heat reserve in one hour.

Dissipation of heat	48.8426
Loss from heat reserve	16.6404
Hourly production of heat	32.2022

SUMMARY.

Production of heat in the hour.	First period	58.8715
	Second period	56.8313
	Third period	32.2022
Loss of heat production in second period		2.0402
Loss of heat production in third period		26.6693

In studying the first of these experiments (Experiment 72) the fall of the bodily temperature immediately following the injection at once attracts attention. This

may fairly be attributed to the complete suspension of respiration; the tightly contracted muscle allowing only sufficient artificial respiration to maintain life. It must of course be remembered that it was essential not to injure the animal, and that consequently artificial respiration was limited to external manipulation. After respiration was re-established the bodily temperature began to rise. The hourly rate of heat production at this time was 79.4947 instead of 34.6575—a remarkable difference. This experiment apparently confirms the results of medullary section, showing that the inhibitory centre is situated at least as high up as the pons.

The next experiment was continued longer, and gave results less readily explained than those just discussed. Immediately after the injection, as well as later, the heat production was found to be much reduced. The autopsy showed a complete destruction of the left cerebellar lobe and peduncle, as well as of the upper portion of the pons. So extensive a lesion may well be expected to cause vaso-motor disturbance, and it has been abundantly proven by the effects of section of the cord that the action of the higher heat-centre is dominated by the vaso-motor system; indeed the effects upon heat dissipation and production, in the experiment, were exactly such as follow section of the cord. The production of vaso-motor palsy seems to me the most plausible explanation of the phenomena noticed. A possible explanation is also afforded by the supposition that the heat-controlling fibres or centres in the pons escaped, the pons having in truth been only partially destroyed. The difficulty of exactly locating the lesion, multiplied as it is by the fact that two injections are of necessity required in the upper brain (one for each side), has deterred me from making many of these injection experiments; the following are all that I have performed:—

Experiment 74.

A small dog. Weight 12 lbs.

Time.	Air Temp. (Fah.)	Tube Temp (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:10 A. M.	68°.24	73°.66	9°.89	102°.92	503
11:30	69.32	72.68			
11:50	70.52	73.25			
12:10 P.	72.05	73.45	70.07	102.38	567
	70.03 (mean)	73.26	0.18 (gain)	0.54 (loss)	64
		70.03			
		3.23 (gain)			

1 P. M.—Injection of strong water of ammonia.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
2:55 A. M.	68°.72	72°.08	70°.736	100°.9	606
3:10	66.29	70.76			
3:25	66.29	70.43			
3:40	70.07	71.15			
3:55	71.36	72.08	70.928	100.9	671
	68.55 (mean)	71.3	0.192 (gain)		65
		68.55			
		2.75 (gain)			

4 P. M.—Dog killed. Left corpus striatum the only part of the brain injured—it totally destroyed

Heat Dissipation.

BEFORE INJECTION.

Quantity of air (V′) = 64 at 73°.26 — 32° = 41.26 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{64}{1.084} = 59.04$. $W = V \times 0.08073 = 4.8$

Rise in temp. of air 3.23 = t. $Q = W \times t \times$ sp. h. $= 4.8 \times 3.23 \times 0.2374 = 3.6806$ = heat given to air.
Rise in temp. of water $0.18 \times 164.1414 = 29.5454$ = heat given to calorimeter.
3.6806 = heat given to air.

Hourly dissipation of heat 33.226

AFTER INJECTION.

Quantity of air (V′) = 65 at 71°.3 — 32° = 39.3 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{65}{1.08} = 60.2$. $W = V \times 0.08073 = 4.86$

Rise in temp. of air 2.75 = t. $Q = W \times t \times$ sp. h. $= 4.86 \times 2.75 \times 0.2374 = 3.1728$ = heat given to air.
Rise in temp. of water $0.192 \times 164.1414 = 31.5152$ = heat given to calorimeter.
3.1728 = heat given to air.

Hourly dissipation of heat 34.688

SUMMARY.

Hourly dissipation of heat after injection	34.688
Hourly dissipation of heat before injection	33.226
Hourly increase of heat dissipation following injection	1.462

Heat Production.

BEFORE INJECTION.

Fall of bodily temperature 0.54 = t′.

$Q = W \times t' \times$ sp. h. $= 12 \times 0.54 \times 0.75 = 4.86$ = hourly loss from heat reserve.

Hourly dissipation of heat	33.226
Loss from heat reserve	4.86
Hourly production of heat	28.366

AFTER INJECTION

No change of bodily temperature.
Hourly dissipation, = hourly production of heat 34.688

SUMMARY.

Hourly production of heat after injection	34.688
Hourly production of heat before injection	28.366
Gain of heat production following injection	6.322

EXPERIMENT 75.

A large dog, weight 36 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:8 P. M.	65°.21	70°.21	65°.165	102°.92	707
1:23	64.13	70.88			
1:38	64.4	70.25			
1:54	64.22	70.25			
2:8	64.88	70.16	66.62	103.28	791.5
	64.57 (mean)	70.35	1.455 (gain)	0.36 (gain	84.5
		64.57			
		5.78 (gain)			

2:30 P. M.—Strong aqua ammoniæ injected into the left brain. Head immediately flexed to the right, no movements. 2:36 P. M.—Rectal temperature, 103°.1.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:56 P. M.	64°.4	68°.54	65°.255	.....	844
3:11	63.73	68.98			
3:26	63.32	68.72			
3:41	63.23	68.27			
3:56	63.92	68.54	66.56	97°.52	926
	63.72 mean)	68.61 63.72	1.305 (gain)		82
	4.89 (gain)				

4:15 P. M.—The feet are very cold. Incoördinate movements of front feet. 9 P. M.—Animal gradually dying.

Autopsy.—Destruction of a large portion of the left optic thalamus, also of the cerebral convolution immediately over this, also of all of the deeper portions of the entire left hemisphere.

Heat Dissipation.

BEFORE INJECTION.

Quantity of air (V′) = 84.5 at 70°.35—32° = 38°.35 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{84.5}{1.078} = 78.3$. $W = V \times 0.08073 = 6.3$

Rise in temp. of air 5.78 = t. $Q = W \times t \times$ sp. h. $= 6.3 \times 5.78 \times 0.2374 = 8.6447$ = heat given to air.

Rise in temp. of water $1.455 \times 164.1414 = 238.8257$ = heat given to calorimeter.
8.6447 = heat given to air.

Hourly dissipation of heat 247.4704

AFTER INJECTION.

Quantity of air (V′) = 82 at 68°.61—32° = 36.61 = t′. $V + (V \times t' \times 0.002035) = V'$.

$V = \frac{82}{1.074} = 76.3$. $W = V \times 0.08073 = 6.16$

Rise in temp. of air 4.89 = t. $Q = W \times t \times$ sp. h. $= 6.16 \times 4.89 \times 0.2374 = 7.1511$ = heat given to air.

Rise in temp. of water $1.305 \times 164.1414 = 214.2045$ = heat given to calorimeter.
7.1511 = heat given to air.

Hourly dissipation of heat 221.3556

SUMMARY.

Hourly dissipation of heat before injection	247.4704
Hourly dissipation of heat after injection	221.3556
Diminution of heat dissipation following injection	26.1148

Heat Production.

BEFORE INJECTION.

Rise of bodily temperature 0.36 = t.

$Q = W \times t \times$ sp. h. $= 36 \times 0.36 \times 0.75 = 9.72$ = heat added to reserve.

Hourly dissipation of heat	247.4704
Hourly gain from heat reserve	9.72
Hourly production of heat	257.1904

After Injection.

Fall of animal temperature in $1\frac{1}{3}$ hours 5.58, in 1 hour 4.185 = t.

Q = W × t × sp. h. = 36 × 4.185 × 0.75 = 112.995 = heat lost from reserve.

Hourly dissipation of heat	221.3556
Hourly loss from heat reserve	112.995
Hourly production of heat	108.3606

Summary

Hourly production of heat before injection	257.1904
Hourly production of heat after injection	108.3606
Diminution of hourly production of heat following injection	148.8298

These experiments do not require extended comment. The first would seem to indicate that in the dog the corpus striatum is connected either directly or by conduction with the function of heat production. The small size of the dog and the consequently minute amount of heat dissipated increases, however, greatly the chances of error, and not very much confidence can be put in the single experiment.

The great diminution of heat production which followed the operation in the second experiment was probably due to shock, *i. e.*, vaso-motor palsy, caused by the destruction of nearly a whole cerebral hemisphere.

The only conclusion to be drawn is that the method employed is a doubtful one, and that no decided light has been thus far thrown upon the position of the inhibitory heat centre by its employment.

Eulenburg and Landois reported in *Virchow's Archiv*, Bd. lxviii., p. 245, a series of experiments upon the effect of destruction of the cerebral cortex on the temperature of the feet of dogs. They found that when a certain region in the neighborhood of the sulcus cruciatus was destroyed either by means of a hot iron or by chemical reagents, almost immediately the temperature of the opposite extremities rose. They assert that in some cases the difference between the feet of the two sides amounted to 13° C. (23°.4 F.), and that occasionally it was only 1°.5 C. (2°.7 F.). They located the exact position of this region as being bordered anteriorly by the sulcus cruciatus, and extending to the fourth primitive convolution embracing especially a "hackenförmig" gyrus which appears to correspond to the gyrus postfrontalis (Owen) in man and apes. They also state that they were able to separate the region presiding over the front from that governing the hinder extremities, the focus for the front legs lying somewhat more forward and in immediate proximity to the distal end of the sulcus cruciatus. Eulenburg and Landois further discovered that when the region was irritated with a galvanic current the paws grew cooler. The duration of the elevation of temperature after destruction of the cerebral temperature varied. In most cases the increased warmth was perceptible for a long time, in some instances for three months; but in some dogs it disappeared after two or three days. Other portions of the cerebral surface than those already spoken of were destroyed without perceptible thermic effect.

This research of Landois and Eulenburg is in accord with that of Prof. E. Hitzig (*Centralblatt für die Med. Wissensch.*, 1876, p. 323), so that the main facts must be considered as almost established. Led by these corroborated statements

of Landois and Eulenburg I have made the following experiments to determine whether destruction of the region indicated by them has any influence upon the general heat production.

Experiment 76.

A dog. Weight 16 lbs.
12:45 P. M.—Rectal temperature 103°.5.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)	Remarks.
1:1 P	73°.94	76°.16	71°.156	138.82	
1:16	73.94	75.08			
1:31	74.39	75.47			
1:46	74.6	75.38			
2:1	75.08	75.47			
2:16	72.73	74.37			
2:31	74.6	75.2	72.203	273.45	
	74.18 (mean)	75.3	1.047 (gain)	134.63	
		74.18			
		1 12 (gain)			

2:45 P. M.—Rect. temp. 102°.9. 3:5 P. M.—Brain burnt with a hot iron. 3:35 P. M.—Rect. temp. 101°.7.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)	Remarks.
3:53 P. M.	77°.36	76°.47	70°.295	284.26	
4:8	75.8	74.3			
4:23	75.65	74.84			
4:38	74.72	74.21			About ½ gallon of water was found in the inner box.
4:53	74.3	74.21			
5:8	73.64	73.84			
5:23	73.94	73.66	71.6	419.	
	75.06	74.5	1.305	134.74	
	74.5	(mean)	(gain)		
	0.56 (loss)				

5:35 P. M.—Rect. temp. 103°. Loss of tactile sense very marked on each side.

11:45 A. M.—Rectal temperature 104°.8.

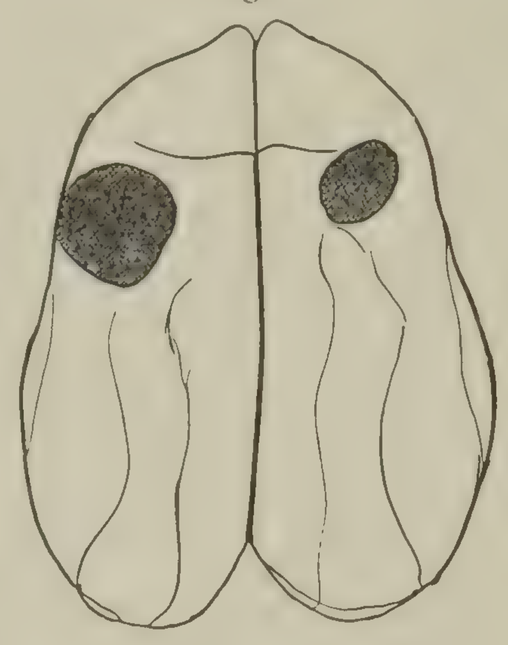
Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)	Remarks.
12:19 P. M.	72°.78	73°.88	70°.448	581.1	
12:34	72,2	73.65			
12:49	71.96	73.55			
1:4	71.96	73.35			A leak in the top of the box caused the whole stratum of sawdust on the lid to be wet through, causing much loss of heat, and making this observation somewhat unreliable.
1:19	71.78	73.45			
1:34	71.87	73.65			
1:49	71.96	73.88			
2:9	71.96	73.66			
2:19	.....	.....	71.69	732.655	
	72.06	73.63	1.242	151.555	
	(mean)	72.06	(gain)		
		1.57 (gain)			

2:30 P. M.—Rectal temperature 104°.8.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)	Remarks.
3:12 P. M.	73°.4	71°.39	71°.24	778.68	
3:22	73.4	73.88			
3:42	73.52	74.12			
5:57	73.4	74.12			
4:12	73.94	74.21	71.897	848.14	
	73.53	73.54	0.657	69.46	
		73.53			
		0.01			

4:15 P. M.—Rectal temperature 105°.4. The dog eats well; can walk well, but the tactile sense in the paws seems almost abolished.

Fig. 1.



Autopsy.—Right side: Wound through the gray matter about one-third of an inch in diameter, involving the outer part of the sulcus cruciatus, and the first, second, and third convolutions. Left side: Wound posterior to sulcus, involving the whole brain beyond the first convolution which escaped, reaching in depth nearly to the ventricle.

Heat Dissipation.

Before Operation.

Quantity of air (V′) = 134.63 at 75°.3 — 32° = 43.3 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{134.63}{1.088} = 123.74$. $W = V \times 0.08073 = 9.99$.

Rise in temp. of air 1.12 = t. $Q = W \times t \times$ sp. h. $= 9.99 \times 1.12 \times 0.2374 = 2.6562$ = heat given to air.

Rise in temp. of water $1.047 \times 130.859 = 137.0094$ = heat given to calorimeter.

2.6562 = heat given to air.

139.6656 = heat dissipated in 1½ hours.

Hourly dissipation of heat 93.1104

After Operation.

First Period—

Quantity of air (V′) = 134.74 at 74°.5 — 32° = 32.5 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V' = \frac{134.74}{1.066} = 126.4$. $W = V \times 0.08073 = 10.2$

Fall in temp. of air = 0.56 = t. $Q = W \times t \times$ sp. h. $= 10.2 \times 0.56 \times 0.2374 = 1.356$ = heat taken from air.

Rise in temp. of water $1.305 \times 130.859 = 170.771$ = heat given to calorimeter.

1.356 = heat taken from air.

169.415 = heat dissipated in 1½ hours.

Hourly dissipation of heat 112.9453

Second Period—

Quantity of air (V′) = 151.555 at 73°.63 — 32° = 41.63 = t′.

$V + (V \times t' \times 0.002034) = V'$. $V = \frac{151.555}{1.085} = 139.7$. $W = V \times 0.08073 = 11.28$.

Rise in temp. of air 1.57 = t. $Q = W \times t \times$ sp. h. $= 11.28 \times 1.57 \times 0.2374 = 4.043$ = heat given to air.

Rise in temp. of water 1.242 × 130.859 = 162.5269 = heat given to calorimeter.
4.043 = heat given to air.

166.5699 = heat dissipated in 2 hours.

Hourly dissipation of heat 83.2849

Third Period—

Quantity of air (V′) = 69.46 at 73°.54 — 32° = 41.54 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{69.46}{1.085} = 64$. $W = V \times 0.08073 = 5.17$.

Rise in temp. of air 0.01 = t. $Q = W \times t \times$ sp. h. $= 5.17 \times 0.01 \times 0.2374 = 0.0042$ = heat given to air.

Rise in temp. of water 0.657 × 130.859 = 85.9743 = heat given to calorimeter.
0.0042 = heat given to air.

Heat dissipated in one hour 85.9786

SUMMARY.

Hourly dissipation of heat before operation		93.1104
Hourly dissipation of heat after operation.	First period	112.9453
	Second period	83.2849
	Third period	85.9786
Gain in dissipation of heat during first period after operation		19.8349
Loss of same second period		9.8255
Loss of same third period		7.1318

Heat Production.

BEFORE OPERATION.

Fall of bodily temperature in 2 hours 0.6, in 1 hour 0.3 = t.

$Q = W \times t \times$ sp. h. $= 16 \times 0.3 \times 0.75 = 3.6$ = heat taken from reserve.
93.1104 = hourly dissipation of heat.

Hourly heat production 89.5104

AFTER OPERATION.

First Period—

Rise of bodily temperature in 2 hours 1.3, in 1 hour 0.65 = t.

$Q = W \times t \times$ sp. h. $= 16 \times 0.65 \times 0.75 = 7.8$ = heat added to reserve.
112.9453 = hourly dissipation of heat.

Hourly production of heat 120.7453

Second Period—

No change in bodily temperature, hourly dissipation = *nourly production of heat* 83.2849

Third Period—

Rise of bodily temperature in $1\frac{3}{4}$ hours 0.6, in 1 hour 0.343 = .

$Q = W \times t \times$ sp. h. $= 16 \times 0.343 \times 0.75 = 4.116$ = heat added to reserve.
85.9786 = hourly dissipation of heat.

Hourly production of heat 90.0946

SUMMARY.

Hourly production of heat before operation		89.5104
Hourly production of heat after operation.	First period	120.7453
	Second period	83.2849
	Third period	90.0946
Hourly gain in heat production immediately following operation		31.2349
Hourly loss of heat production, second period, following operation		6.2255
Hourly gain of heat production, third period, following operation		0.5842

Experiment 77.

A dog. Weight 16 pounds.

April 1, 1:45 P. M.—Rectal temperature 104°.1.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
1:55 P. M.	70°.88	73°.98	69°.98	.....	687.91
2:10	69.92	73.45			
2:25	70.04	71.84			
2:40	70.34	71.6			
2:55	70 34	72.08			
3:10	71.96	73.14	70.43	104°.1	839.5
	70.58 (mean)	72 68	0.45 (gain)		151.59
		70.58			
		2.1 (gain)			

3:20 P. M.—Rectal temperature, 104°.1. 3:30 P. M.—Brain operated on.

3:45 P. M.—Rectal temperature, 104°.6. Animal not fully recovered from anæsthetics.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
4:5 P. M.	74°.21	75°.92	71°.	.....	890.6
4:20	73.4	75.38			
4:35	73.4	74.96			
4:50	73.3	74.	.....	.....	1001.3
5:5	.....	.....	71.48		
	73.58 (mean)	75.06	0.48 (gain)		110.7
		73.58			
		1.48 (gain)			

5:15 P. M.—Rectal temperature, 102°.4.

April 2.—Dog in good condition; but the scalp wound suppurating and some brain matter escaping. He has had nothing to eat since the operation.

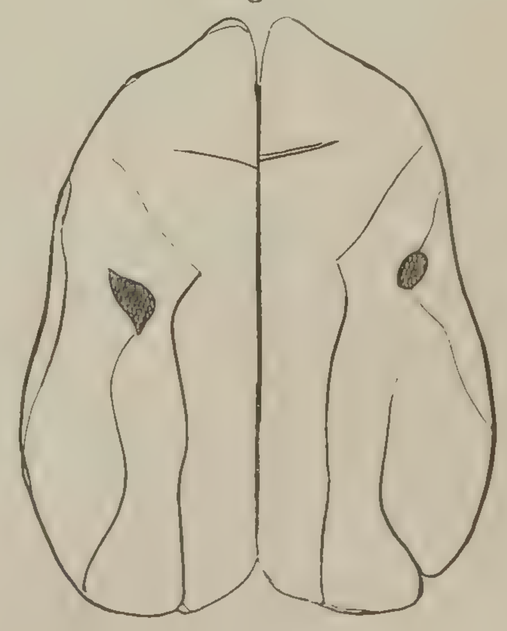
12 M.—Rectal temperature 103°.3.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:19 P. M	70°.04	71°.6	68°.18	.....	104 03
12:34	69.2	71.06			
12:49	69.32	70.97			
1:4	69.32	70.97			
1:19	69.4	71.06			
1:34	70.34	71.42	68.765	.....	210.71
	69.6 (mean)	71.18	0.585 (gain)		106.68
		69.6			
		1.58 (gain)			

1:45 P. M.—Recta. temperature 103°.9.

April 3.—Animal killed.

Fig. 2.



Autopsy.—Brain: Right side; a small deep lacerated wound reaching nearly to the ventricle, and situated at the extreme outer edge of the second convolution nearly half-way back from the front. Left side; a large lacerated pulpified wound, chiefly occupying the third convolution, but to some extent involving the outer edge of the second, reaching about half-way to the ventricle. (See Fig. 2.)

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V′) = 151.59 at 72°.68—32° = 40.68 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{151.59}{1.083} = 140$. $W = V \times 0.08073 = 11.3$

Rise in temp. of air 2.1 = t. $Q = W \times t \times$ sp. h. $= 11.3 \times 2.1 \times 0.2374 = 5.6335$ = heat given to air.

Rise in temp. of water $0.45 \times 130.859 = 58.8865$ = heat given to calorimeter.

5.6335 = heat given to air.

64.52 = heat dissipated in $1\frac{1}{4}$ hours.

Hourly dissipation of heat 51.616

AFTER OPERATION.

1st Period—

Quantity of air (V′) = 110.7 at 75°.06—32° = 43.06 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{110.7}{1.087} = 102$. $W = V \times 0.08073 = 8.2$

Rise in temp. of air 1.48 = t. $Q = W \times t \times$ sp. h. $= 8.2 \times 1.48 \times 0.2374 = 2.811$ = heat given to air.

Rise in temp. of water $0.48 \times 130.859 = 62.8123$ = heat given to calorimeter.

2.811 = heat given to air.

Hourly dissipation of heat 65.6233

2d Period—

Quantity of air (V′) = 106.68 at 71°.18—32° = 39.18 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{106.68}{1.08} = 98.8$. $W = V \times 0.08075 = 8$

Rise in temp. of air 1.58 = t. $Q = W \times t \times$ sp. h. $= 8 \times 1.58 \times 0.2374 = 3.0007$ = heat given to air.

Rise in temp. of water $0.585 \times 130.859 = 76.5525$ = heat given to calorimeter.

3.0007 = heat given to air.

79.5532 = heat dissipated in $1\frac{1}{4}$ hours.

Hourly dissipation of heat 63.6426

SUMMARY.

Hourly dissipation of heat before operation		51.616
Hourly dissipation of heat after operation.	1st period	65.6233
	2d period	63.6426
Gain of heat dissipation following operation.	*1st period*	14.0073
	2d period	12.0266

Heat Production.

BEFORE OPERATION.

No change in bodily temperature.

Hourly dissipation = *hourly production of heat* 51.616

AFTER OPERATION.

1st Period—

Fall of bodily temperature in $1\frac{1}{2}$ hours 2.2, in 1 hour 1.47 = t.

$Q = W \times t \times$ sp. h $= 16 \times 1.47 \times 0.75 = 17.64$ = heat lost from reserve.

Heat dissipated in 1 hour 65.6233

Heat lost from reserve in 1 hour 17.64

Hourly production of heat 47.9833

2d Period—

Rise of bodily temperature in $1\frac{3}{4}$ hours 0.6, in 1 hour 0.343 = t.

$Q = W \times t \times$ sp. h. $= 16 \times 0.343 \times 0.75 = 4.116$ = heat added to reserve.

Heat dissipated in 1 hour	63.6426
Heat added to reserve	4.116
Hourly production of heat	67.7586

SUMMARY.

Hourly production of heat before operation		51.616
Hourly production of heat after operation.	1st period	47.9833
	2d period	67.7586
Loss of hourly production of heat immediately following operation		3.6327
Gain of hourly production of heat subsequent day after operation		16.1426

EXPERIMENT 78.

A dog. Weight 16.5 pounds.

April 22, 11:50 A. M.—Rectal temperature 102°.7.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:3 P. M.	73°.09	75°.47	74°.129	756.4
12:20	72.73	75.2		
12:35	72.63	74.84		
12:51	72.47	74.84		
1:5	72.73	75.68		
1:18	72.42	74.3	74.504	870.64
	72.68 (mean)	75.05 72.68	0.375 (gain)	114.24
		2.37 (gain)		

1:20 P. M.—Rectal temperature 103°.6. 2 P. M.—Brain washed out freely through trephine openings over Hitzig's region.

April 23, 12:20 P. M.—Rectal temperature 103°.6.

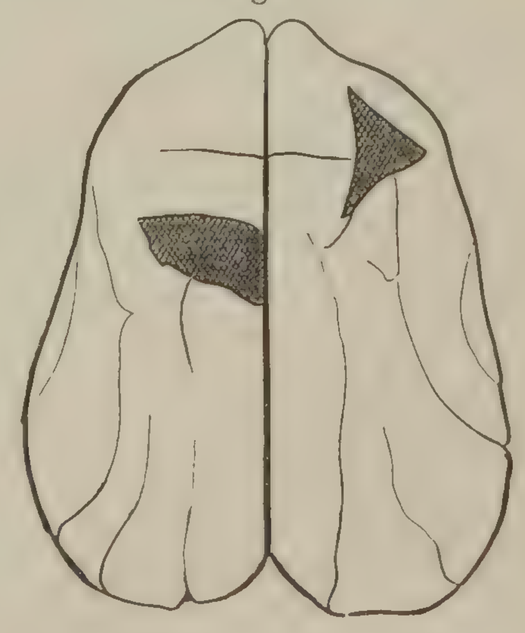
TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:32 P. M.	64°.76	72°.32	70°.34	933.78
12:47	69.55	71.51		
1:2	70.43	72.08		
1:17	70.04	72.86		
1:32	70.04	72.77		
1:47	72.32	74.03		
2:2	71.78	73.66	71.24	1063.696
	69.84 (mean)	72.75 69.84	0.9 (gain)	129.916
		2.91 (gain)		

2:10 P. M.—Rectal temperature 103°.

April 25.—Dog beginning to eat.

April 27.—Dog able to walk some.

Fig. 3.



May 3.—Dog killed. Right side of brain; a very large wound, involving 1, 2, 3, 4 primitive convolutions, running across the sulcus cruciatus and extending into the ventricles. Left side; wound about one-third of an inch posterior to the sulcus cruciatus, involving 1, 2, 3 convolutions, and extending into the ventricles. (See Fig. 3.)

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V′) = 114.24 at 75°.05—32° = 43.05 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{114.24}{1.088} = 105$. $W = V \times 0.08073 = 8.48$

Rise in temp. of air 2.37 = t. $Q = W \times t \times$ sp. h. $= 8.48 \times 2.37 \times 0.2374 = 4.7688$ = heat given to air.

Rise in temp. of water $0.375 \times 130.859 = 49.0721$ = heat given to calorimeter.

4.7688 = heat given to air.

53.8409 = heat dissipated in $1\frac{1}{4}$ hours.

Hourly dissipation of heat 43.0727

DAY FOLLOWING OPERATION.

Quantity of air (V′) = 129.916 at 72°.75—32° = 40.75 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{129.916}{1.083} = 120$. $W = V \times 0.08073 = 9.69$

Rise in temp. of air 2.91 = t. $Q = W \times t \times$ sp. h. $= 9.69 \times 2.91 \times 0.2374 = 6.6942$ = heat given to air.

Rise in temp. of water $0.9 \times 130.859 = 117.7731$ = heat given to calorimeter.

6.6942 = heat given to air.

124.4673 = heat dissipated in $1\frac{1}{2}$ hours.

Hourly dissipation of heat 82.9782

SUMMARY.

Hourly dissipation of heat before operation	43.0727
Hourly dissipation of heat day following operation	82.9782
Gain in hourly dissipation of heat	39.9055

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in $1\frac{1}{4}$ hours 0°.9, in 1 hour 0.72 = t.

$Q = W \times t \times$ sp. h. $= 16.5 \times 0.72 \times 0.75 = 8.91$ = heat added to reserve.

Heat dissipated in 1 hour	43.0727
Heat added to reserve	8.91
Hourly production of heat	51.9827

AFTER OPERATION.

Fall of bodily temperature in $1\frac{1}{2}$ hours 0°.6, in 1 hour 0.4 = t.

$Q = W \times t \times$ sp. h. $= 16.5 \times 0.4 \times 0.75 = 4.95$ = heat taken from reserve.

Heat dissipated in 1 hour	82.9782
Heat taken from reserve	4.95
Hourly production of heat	78.0282

SUMMARY.

Hourly production of heat day after operation	78.0282
Hourly production of heat day before operation	51.9827
Gain of hourly heat production following operation	26.0455

Experiment 79.

A dog. Weight 18.25 pounds.
March 21.—Dog fed about 10 A. M. 11:15 A. M.—Rectal temperature 103°.8.

Time.	Air Temp. (Fah.)	Tube Temp. Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:30 A. M.	.....	.....	67°.55	269.59
11:45	.....	.....		
12 M.	60°.2	68°.12		
12:15 P. M.	63.32	68.		
12:30	59.7	67.88	68.636	333.15
	61.07 (mean)	68 61.07	1.086 (gain)	63.56
		6.93 (gain)		

12:40 P. M.—Rectal temperature 103°.4. 1 P. M.—Brain operated upon. 1:10 P. M.—Rectal temperature 101°.6. 1:15 P. M.—Rectal temperature 103°. Dog has a very distinct loss of tactile sense on each side, with marked sprawling movements, and the rooster tread or gait.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
1:19 P. M.	64°.67	70°.09	67°.01	420.72
1:34	64.13	69.53		
2:4	62.6	69.08		
2:19	61.9	68.36	68.252	454.5
	63.32 (mean)	69.26 63.32	1.242 (gain)	33.78
		5.94 (gain)		

2:30 P. M.—Rectal temperature 102°.5.
March 22.—The dog has not had any food since 10 A. M., March 21.
3:39 P. M.—Rectal temperature 102°.7.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:50 P. M.	66°.2	69°.62	67°.271	503.7
4:5	64.22	69.08		
4:20	64.04	69.08		
4:35	64.31	67.76		
4:50	64.22	68.54	68.135	542.
	64.6 (mean)	68.8 64.6	0.864 (gain)	38.3
		4.2 (gain)		

4:54 P. M.—Rectal temperature 103°.
Animal died during the night. *Autopsy.*—Right side of the brain uninjured; region of the left sulcus cruciatus destroyed; also the whole corpus callosum.

Before Operation.

Quantity of air (V′) = 63.56 at 68° − 32° = 36 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{63.56}{1.073} = 59.2$. $W = V \times 0.08073 = 4.78$

Rise in temp. of air 6.93 = t. $Q = W \times t \times$ sp. h. $= 4.78 \times 6.93 \times 0.2374 = 7.864$ = heat given to air.
Rise in temp. of water $1.086 \times 130.859 = 142.1129$ = heat given to calorimeter.
7.864 = heat given to air.

Hourly dissipation of heat 149.9769

AFTER OPERATION.

First Period—

Quantity of air (V′) = 33.78 at 69°.26 — 32° = 37.26 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{33.78}{1.076} = 31.4$. $W = V \times 0.08073 = 2.53$

Rise in temp. of air 5.94 = t. $Q = W \times t \times$ sp. h. $= 2.53 \times 5.94 \times 0.2374 = 3.5677$ = heat given to air.

Rise in temp. of water $1.242 \times 130.859 = 162.5268$ = heat given to calorimeter.

3.5677 = heat given to air.

Heat dissipated in one hour 166.0945

Second Period—

Quantity of air (V′) = 38.3 at 68°.8 — 32° = 36.8 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{38.3}{1.075} = 35.6$. $W = V \times 0.08073 = 2.87$

Rise in temp. of air 4.2 = t. $Q = W \times t \times$ sp. h. $= 2.87 \times 4.2 \times 0.2374 = 2.8682$ = heat given to air.

Rise in temp. of water $0.864 \times 130.859 = 113.0622$ = heat given to calorimeter.

2.8682 = heat given to air.

Hourly dissipation of heat 115.9304

SUMMARY.

Hourly dissipation of heat before operation		149.9769
Hourly dissipation of heat after operation:	First period	166.0945
	Second period	115.9304
Gain in hourly dissipation of heat during first period after operation		16.1176
Loss in hourly dissipation of heat during second period after operation		34.0465

Heat Production.

BEFORE OPERATION.

Fall of animal temperature in 1½ hours 0°.4, in 1 hour 0.267 = t.

$Q = W \times t \times$ sp. h. $= 18.25 \times 0.267 \times 0.75 = 3.6555$ = heat taken from reserve.

149.9769 = heat dissipated in one hour.

3.6555 = heat taken from reserve.

Hourly production of heat 146.3214

AFTER OPERATION.

First Period—

Fall of animal temperature in 1½ hours 0°.5, in 1 hour 0.334 = t.

$Q = W \times t \times$ sp. h. $= 18.25 \times 0.334 \times 0.75 = 4.5716$ = heat taken from reserve.

166.0945 = hourly dissipation of heat.

4.5716 = heat taken from reserve.

Hourly production of heat 161.5229

Second Period—

Rise of animal temperature in 1¼ hours 0°.3, in 1 hour 0.24 = t.

$Q = W \times t \times$ sp. h. $= 18.25 \times 0.24 \times 0.75 = 3.275$ = heat added to reserve.

115.9304 = hourly dissipation of heat.

3.275 = heat added to reserve.

Hourly production of heat 119.2054

SUMMARY.

Hourly production of heat before operation		146.3214
Hourly production of heat after operation:	First period	161.5229
	Second period	119.2054
Gain in heat production during first period after operation		15.2015
Loss of heat production during second period after operation		27.116

Experiment 80.

A dog. Weight 10.5 pounds.

April 5. 11:20 A. M.—Rectal temperature 104°.2.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:55 A. M.	64°.22	71°.12	71°.24	542.72
12:10 P. M.	67.55	72.5		
12:25	67.64	72.5		
12:40	67.04	72.41		
12:55	67.55	72.68	71.69	672
	66.8 (mean)	72.24	0.45 (gain)	129.28
		66.8		
		5.44 (gain)		

1:10 P. M.—Rectal temperature 104°.9. 1:20 P. M.—Brain operated on during ether narcosis.
1:30 P. M.—Rectal temperature 102°.25.

Time.	Air Temp. (Fah.)	Tube Temp (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
1:48 P. M.	68°.81	69°.44	67°.55	712
2:3	67.55	68.72		
2:18	67.16	68.72		
2:33	67 64	69.8		
2:48	68	69.44	68.48	809.22
	67.83 (mean)	69.22	0.93 (gain)	97.22
		67.83		
		1.39 (gain)		

3 P. M.—Rectal temperature 103°.25.

April 8.—Symptoms of loss of tactile sense, decided in all four extremities, but most marked anteriorly. Dog killed.

Fig. 4.



Autopsy.—Brain with very many secondary convolutions obscuring primary. Two large wounds; left side, situated upon the sulcus cruciatus, involving first and second convolutions, extending through the gray matter. Right side; wound involving the first convolution about one-fourth of an inch posterior to the sulcus, and extending two-thirds through the gray matter.

Heat Dissipation.

Before Operation.

Quantity of air (V′) = 129.28 at 72°.24—32° = 40.24 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{129.28}{1.082} = 119.5$ $W = V \times 0.08073 = 9.61$

Rise in temp. of air 5.44 = t. $Q = W \times t \times$ sp. h. $= 9.61 \times 5.44 \times 0.2374 = 12.4109$ = heat given to air.

Rise in temp. of water $0.45 \times 130.859 = 58.8865$ = heat given to calorimeter.

12.4109 = heat given to air.

Hourly dissipation of heat 71.2974

After Operation.

Quantity of air (V′) = 97.22 at 69°.22 — 32° = 37.22 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{97.22}{1.076} = 90.3$. $Q = V \times 0.08073 = 7.3$

Rise in temp. of air 1.39 = t. $Q = W \times t \times$ sp. h. $= 7.3 \times 1.39 \times 0.2374 = 2.4089$ = heat given to air.

Rise in temp. of water $0.93 \times 130.859 = 121.6989$ = heat given to calorimeter.
2.4089 = heat given to air.

Hourly dissipation of heat 124.1078

Summary.

Hourly dissipation of heat before operation	71.2974
Hourly dissipation of heat after operation	124.1078
Hourly gain of dissipation of heat following operation	52.8104

Heat Production.

Before Operation.

Rise of bodily temperature in $1\frac{5}{6}$ hours 0°.7, in 1 hour 0.382 = t.
$Q = W \times t \times$ sp. h. $= 10.5 \times 0.382 \times 0.75 = 3.0082$ = heat added to reserve.
3.0082 = heat added to reserve.
71.2974 = heat dissipated hourly.

Hourly heat production 74.3056

After Operation.

Rise of bodily temperature in $1\frac{1}{2}$ hours 1°, in 1 hour 0.666 = t.
$Q = W \times t \times$ sp. h. $= 10.5 \times 0.666 \times 0.75 = 5.25$ = heat added to reserve.
5.25 = heat added to reserve.
124.1078 = heat dissipated hourly.

Hourly heat production 129.3578

Summary.

Hourly heat production after operation	129.3578
Hourly heat production before operation	74.3056
Hourly increase of heat production following operation	55.0522

Experiment 81.

A cur. Weight 16 lbs.
March 26. 12:35 P. M.—Rectal temperature 103°.9.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:42 P. M.	67°.04	72°.68	70°.25	806.1
1:2	66.38	72.68		
1:17	66.29	71.24		
1:32	68.24	71.06		
1:47	69.44	71.72		
2:2	69.32	71.72		
2:12	70.12	71.96	70.989	1001.84
	68.12 (mean)	71.87	0.739 (gain)	195.74
		68.12		
		3.75 (gain)		

2:20 P. M.—Rectal temperature 103°.9. 2:45 P. M.—Brain operated on with a cataract needle through trephine openings in the skull.

3 P. M.—Rectal temperature 104°.5.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:23 P. M.	71°.96	73°.35	71°	1058.6
3:38	71.15	73.35		
3:53	71.03	73.04		
4:20	70.52	73.04		
4:35	69.88	73.45		
4:53	70.88	73.55	71.97	1218.74
	70.9 (mean)	73.3	0.97 (gain)	160.14
		70.9		
		2.4 (gain)		

5 P. M.—Rectal temperature 104°.5. 5:30 P. M.—Dog fed.

March 27. 11:45 A. M.—Rectal temperature 104°.9.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:7 P. M.	71°.73	73°.88	72°.05	286.61
12:20	70.97	73.66		
12:35	70.88	73.14		
12:50	70.43	73.04		
1:7	70.64	73.04		
1:22	70.16	72.86		
1:37	71.24	73.55	73.058	408.79
	70.86 (mean)	73.31	1.008 (gain)	122.18
		70.86		
		2.45 (gain)		

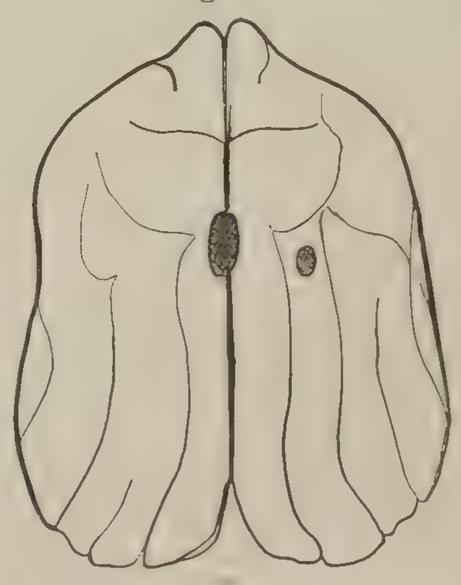
1:45 P. M.—Rectal temperature 105°.4. Dog at times has a sprawling gait, but the loss of tactile sense is not distinct. 5:30 P. M.—Dog fed.

March 28. 12:40 P. M.—Rectal temperature 105°.5.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:45 P. M.	60°.2	65°.39	64°.31	434.35
1	61.7	66.08		
1:15	64.22	67.13		
1:30	65	67.43		
1:45	63.68	66.8		
2	67.64	68.27		
2:15	70.16	68.72	65.408	587.04
	64.66 (mean)	67.12	1.098 (gain)	152.69
		64.66		
		2.46 (gain)		

2:25 P. M.—Rectal temperature 105°.5.

Fig. 5.



Dog killed March 28. *Autopsy.*—Two orifices in the skull—one directly over the median sinus, a piece of bone pushed down on the brain, but no wound of the brain. One orifice in the neighborhood of Hitzig's region of the right hemisphere. Here a deep lacerated wound of brain, situated in the second primitive convolution, about half an inch posterior to the sulcus cruciatus, and reaching almost to the corpus striatum.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V′) = 195.74 at 71°.87 — 32° = 39.87 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{195.74}{1.081} = 181.1$. $W = V \times 0.08073 = 14.62$

Rise in temp. of air 3.75 = t. $Q = W \times t \times$ sp. h. $= 14.62 \times 3.75 \times 0.2374 = 12.9976$ = heat given to air.

Rise in temp. of water $0.739 \times 130.859 = 96.7048$ = heat given to calorimeter.

12.9976 = heat given to air.

109.7024 = heat dissipated in 1½ hours.

Hourly dissipation of heat 73.1349

AFTER OPERATION.

First Period—

Quantity of air (V′) = 160.14 at 73°.3 — 32° = 41.3 = t′.

$V + (V \times t' \times 0.002035) = V$. $V = \frac{160.14}{1.084} = 147.7$. $W = V \times 0.08073 = 11.9$

Rise in temp. of air 2.4 = t. $Q = W \times t \times$ sp. h. $= 11.9 \times 2.4 \times 0.2374 = 6.7801$ = heat given to air.

Rise in temp. of water $0.97 \times 130.859 = 126.9332$ = heat given to calorimeter.

6.7801 = heat given to air.

133.7133 = heat dissipated in 1½ hours.

Hourly dissipation of heat 89.1422

Second Period—

Quantity of air (V′) = 122.18 at 73°.31 — 32° = 41.31 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{122.18}{1.084} = 112.7$. $W = V \times 0.08073 = 9.1$

Rise in temp. of air 2.45 = t. $Q = W \times t \times$ sp. h. $= 9.1 \times 2.45 \times 0.2374 = 5.2928$ = heat given to air.

Rise in temp. of water $1.008 \times 130.859 = 131.9059$ = heat given to calorimeter.

5.2928 = heat given to air.

137.1987 = heat dissipated in 1½ hours.

Hourly dissipation of heat 91.4658

Third Period—

Quantity of air (V′) = 152.69 at 67°.12 — 32° = 35.12 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{152.69}{1.071} = 142.6$. $W = V \times 0.08073 = 11.5$

Rise in temp. of air 2.46 = t. $Q = W \times t \times$ sp. h. $= 11.5 \times 2.46 \times 0.2374 = 6.716$ = heat given to air.

Rise in temp. of water $1.098 \times 130.859 = 143.6832$ = heat given to calorimeter.

6.716 = heat given to air.

150.3992 = heat dissipated in 1½ hours.

Hourly dissipation of heat 100.2661

SUMMARY.

Hourly dissipation of heat before operation		73.1349
Hourly dissipation of heat after operation:	First period	89.1422
	Second period	91.4658
	Third period	100.2661
Gain of heat dissipation following operation:	First period	16.0073
	Second period	18.3309
	Third period	27.1312

Heat Production.

BEFORE OPERATION.

No change of bodily temperature, hourly heat dissipation = *hourly heat production* 73.1349

After Operation.

First Period—No change of bodily temperature.

Hourly dissipation of heat = *hourly production of heat* 89.1422

Second Period—Rise of bodily temperature in 2 hours 0°.5, in 1 hour 0.25 = t.

Q = W × t × sp. h. = 16 × 0.25 × 0.75 = 3 = heat added to reserve.

91.4658 = heat dissipated hourly.

Hourly production of heat 94.4658

Third Period—No change of bodily temperature.

Hourly dissipation of heat = *hourly production of heat* 100.2661

Summary.

Hourly production of heat before operation		73.1349
Hourly production of heat after operation:	First period	89.1422
	Second period	91.4658
	Third period	100.2661
Gain of hourly production of heat following operation:	*First period*	16.0073
	Second period	18.3309
	Third period	27.1312

Experiment 82.

A large dog. Weight 47.8 pounds.

April 30, 12:30 P. M.—Rectal temperature 103°.4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:44 P. M.	63°.92	70°.25	68°.99	256.52
12:59	64.58	71.33		
1:14	65	71.6		
1:29	64.58	71.42		
1:45	64.22	71.33		
1:59	65.12	71.33		
2:14	67.16	71.33		
2:29	67.48	71.24	70.79	335.47
	65 25 (mean)	71.23	1.8 (gain)	78.95
		65.25		
		5.98 (gain)		

2:45 P. M.—Rectal temperature 104°.7. 3.15 P. M.—Brain injured. 3:50 P. M.—Rectal temperature 102°.9.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
4:17 P. M.	70°.06	73°.88	68°.64	396.4
4:32	70.16	73.24		
4:47	70.16	73.35		
5:2	70.04	73.66		
5:17	70.34	73.66		
5:32	71.33	73.56	70.52	448.26
	70.35 (mean)	73.56	1.88 (gain)	51.86
		70.35		
		3.21 (gain)		

5:35 P. M.—Rectal temperature 103°.8.

Autopsy.—Both sides of brain symmetrically wounded, along the whole length of the sinus cruciatus extending a little in front of it and one-quarter of an inch posterior to it and reaching into the ventricles.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V′) = 78.95 at 71°.23 — 32° = 39.23 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{78.95}{1.08} = 73.1$. $W = V \times 0.08073 = 5.9$

Rise in temp. of air 5.98 = t. $Q = W \times t \times$ sp. h. $= 5.9 \times 5.98 \times 0.2374 = 8.3759$ = heat given to air.

Rise in temp. of water $1.8 \times 130.859 = 235.5462$ = heat given to calorimeter.

8.3759 = heat given to air.

243.9221 = heat dissipated in $1\frac{3}{4}$ hours.

Hourly dissipation of heat 139.3841

AFTER OPERATION.

Quantity of air (V′) = 51.86 at 73°.56 — 32° = 41.56 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{51.86}{1.085} = 47.8$. $W = V \times 0.08073 = 3.86$

Rise in temp. of air 3.21 = t. $Q = W \times t \times$ sp. h. $= 3.86 \times 3.21 \times 0.2374 = 2.9415$ = heat given to air.

Rise in temp. of water $1.88 \times 130.859 = 246.0149$ = heat given to calorimeter.

2.9415 = heat given to air.

248.9564 = heat dissipated in $1\frac{1}{4}$ hours.

Hourly dissipation of heat 199.1651

SUMMARY.

Hourly dissipation of heat after operation	199.1651
Hourly dissipation of heat before operation	139.3841
Hourly gain of heat dissipation following operation	59.781

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in $2\frac{1}{4}$ hours 1°.3, in 1 hour 0.577 = t.

$Q = W \times t \times$ sp. h. $= 47.8 \times 0.577 \times 0.75 = 20.6855$ = hourly gain of heat reserve.

139.3841 = hourly dissipation of heat.

20.6855 = hourly gain of heat reserve.

Hourly production of heat 160.0696

AFTER OPERATION.

Rise of bodily temperature in $1\frac{3}{4}$ hours 0°.9, in 1 hour 0.514 = t.

$Q = W \times t \times$ sp. h. $= 47.8 \times 0.514 \times 0.75 = 18.4269$ = hourly gain of heat reserve.

199.1651 = hourly dissipation of heat.

18.4269 = hourly gain of heat reserve.

Hourly production of heat 217.592

SUMMARY.

Hourly production of heat after operation	217.592
Hourly production of heat before operation	160.0696
Hourly gain of heat production after operation	57.5224

15 June, 1880.

Experiment 83.

A cur dog. Weight 15.25 pounds.

11:25 P. M.—Rectal temperature 101°.2. Paw temperature 92°.8.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:39 A. M.	.....	.....	65°.39	116.32
11:45	65°.75	67°.69		
12 M.	67.28	67.69		
12:15 P. M.	67.55	68		
12:30	67.76	68.18		
12:45	68.12	68.27		
1	68.12	68.27		
1:15	69.36	68.63		
1:30	69.20	68.84		
1:39	.....	.....	67.16	233.35
	67.9 (mean)	68.2 67.9	1.77 (gain)	117.03
		0.3 (gain)		

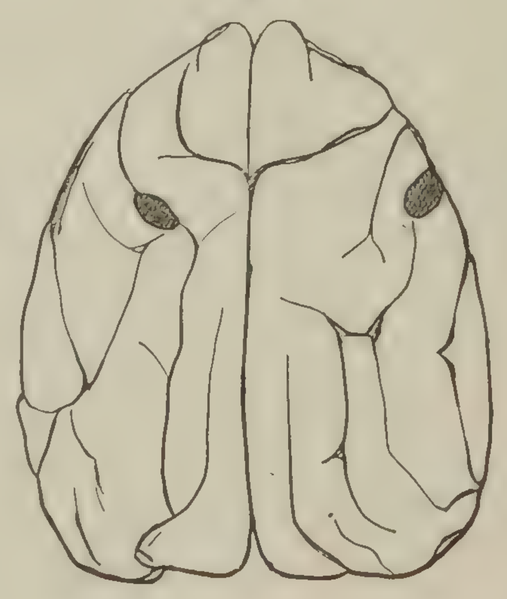
1:45 P. M.—Rectal temperature 101°.6. 1:50 P. M.—Brain operated on mechanically.

2:25 P. M.—Rectal temperature 101°.6. Paw temperature 97°.4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
2:34 P. M.	.....	.....	67°.46	238
2:45	69°.71	70°.34		
3	70.77	70.43		
3:15	70.34	70.61		
3:30	70.52	70.61		
4	69.36	71.15		
4:15	70.43	70.97		
4:34	.....	.....	68.927	341
	70.19 (mean)	70.69	1.467 (gain)	103
		0.5 (gain)		

4:40 P. M.—Rectal temperature 101°.4.

Fig. 6.



Autopsy.—Left wound small, but very deep, piercing the second convolution about four lines posterior to the sulcus cruciatus and extending into the ventricle. Right wound involving the third convolution only, nearly corresponding in anterior position to the other wound. (Fig. 6.)

Heat Dissipation.

Before Operation.

Quantity of air (V′) = 117.03 at 68°.2 − 32° = 36.2 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{117.03}{1.074} = 109.$ $W = V \times 0.08073 = 8.8$

Rise in temp. of air 0.3 = t. $Q = W \times t \times$ sp. h. $= 8.8 \times 0.3 \times 0.2374 = 0.6267$ = heat taken from air.

Rise in temp. of water $1.77 \times 130.859 = 231.6204$ = heat given to calorimeter.

0.6267 = heat given to air.

232.2471 = heat dissipated in 2 hours.

Hourly dissipation of heat 116.1236

After Operation.

Quantity of air (V′) = 103 at 70°.69 — 32° = 38.69 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{103}{1.79} = 95.5$. $W = V \times 0.08073 = 7.7$

Rise in temp. of air 0.5 = t. $Q = W \times t \times$ sp. h. $= 7.7 \times 0.5 \times 0.2374 = 0.914$ = heat given to air.

Rise in temp. of water 1.467 × 130.859	= 191.97	= heat given to calorimeter.
	0.914	= heat given to air.
	192.884	= heat dissipated in 2 hours.
Hourly dissipation of heat	96.442	

Summary.

Hourly dissipation of heat before operation	116.1236
Hourly dissipation of heat after operation	96.442
Loss in hourly heat dissipation following operation	19.6816

Heat Production.

Before Operation.

Rise of bodily temperature in 2 hours 0°.4, in 1 hour 0.2 = t.

$Q = W \times t \times$ sp. h. $= 15.25 \times 0.2 \times 0.75 = 2.2875$ = heat added to reserve.

116.1236	= hourly dissipation of heat.
2.2875	= heat added hourly to reserve
118.4111	
Hourly production of heat	118.4111

After Operation.

Fall of bodily temperature in 2 hours 0.2, in 1 hour 0.1 = t.

$Q = W \times t \times$ sp. h. $= 15.25 \times 0.1 \times 0.75 = 1.1437$ = heat lost from reserve.

96.442	= hourly dissipation of heat.
1.1437	= heat hourly lost from reserve
Hourly production of heat	95.2983

Summary.

Hourly production of heat before operation	118.4111
Hourly production of heat after operation	95.2983
Hourly loss of heat production following operation	23.1128

Experiment 84.

A cur. Weight 14.5 pounds.

June 12.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:39 P. M.	.....	.....	63°.41	102°.2	720.7
12:45	64°.67	66°.8			
1	61	65.84			
1:15	63.04	66.20			
1:30	65.12	67.02			
1:45	65.48	67.02			
2	65.39	66.68			
2:15	65.39	66.56			
2:39	.....	66.68	65.39	102.8	843.54
	64.3 (mean)	66.6	1.98 (gain)	0.6 (gain)	122.84
		64.3			
		2.3 (gain)			

3 P. M.—Brain operated on, mechanical destruction; very violent circus movements at once came on. 3:15 P. M.—Dog quiet.

3:25 P. M.—Rectal temperature 102°.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:46 P. M.	.....	.....	65°.876	102°	856
3:50	63°.8	68°			
4:5	64.76	68			
4:20	64.88	68			
4:35	65.30	67.16			
4:50	65.84	67.16			
5:5	.....	.....			
5:16	.....	.....	67.1	102.2	951.8
	64.91 (mean)	67.66	1.224 (gain)	0.2	95.8
		64.91			
		2.65 (gain)			

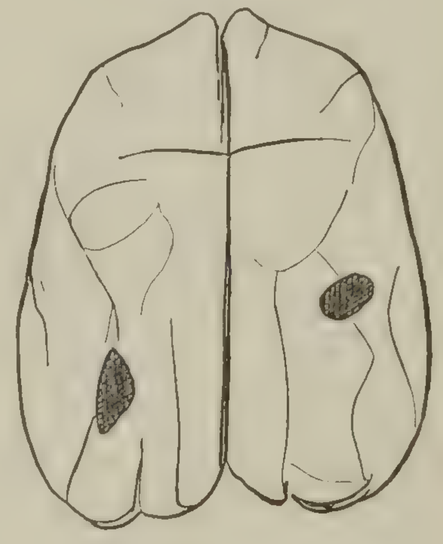
June 13.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
1:10 P. M.	.....	.....	63°.545	102°.2	963.87
1:15	67°.88	66°.8			
1:30	67.76	66.8			
1:45	66.08	66.92			
2	68.24	67.13			
2:15	69.53	67.69			
2:30	69.44	67.69			
2:45	70.25	57.9			
3:10	.....	.....	65.435	102.8	1085.28
	68.45	67.28	1.89	0.6	121.41
	67.28	(mean)	(gain)	(gain)	
	1.17 (loss)				

There is no palsy and no loss of tactile sense.

Autopsy.—Right side of brain: large wound reaching clear through to the ventricle, involving the whole of second and third convolutions, and to some extent, the third and fourth, situated about half-way between the sulcus cruciatus and the posterior brain margin. Left side: wound almost two-thirds the way from the sulcus to the posterior margin, involving the third convolution and part of the fourth and second, reaching nearly to the ventricle. (Fig. 7.)

Fig. 7.



Heat Dissipation.

Before Operation.

Quantity of air (V′) = 122.84 at 66°.6 — 32° = 34.6 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{122.84}{1.07} = 114.8$. $W = V \times 0.08073 = 9.27$

Rise in temp. of air 2.3 = t. $Q = W \times t \times$ sp. h. $= 9.27 \times 2.3 \times 0.2374 = 5.0616$ = heat given to air.

Rise in temp. of water $1.98 \times 130.8589 = 259.1006$ = heat given to calorimeter.

5.0616 = heat given to air.

264.1622 = heat dissipated in two hours.

Hourly dissipation of heat 132.0811

AFTER OPERATION.

1st Period—

Quantity of air (V′) = 95.8 at 67°.66 — 32° = 35.66 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{95.8}{1.072} = 89.4$. $W = V \times 0.08073 = 7.21$

Rise in temp. of air 2.65 = t. $Q = W \times t \times$ sp. h. $= 7.21 \times 2.65 \times 0.2374 = 4.7733$ = heat given to air.

Rise in temp. of water $1.224 \times 130.8589 = 160.1713$ = heat given to calorimeter.

4.7733 = heat given to air.

164.9446 = heat dissipated in 1½ hours.

Hourly dissipation of heat 109.9631

2d Period—

Quantity of air (V′) = 121.41 at 67°.28 — 32° = 35.28 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{121.41}{1.072} = 113.$ $W = V \times 0.08073 = 9.1$

Fall in temp. of air 1.17 = t. $Q = W \times t \times$ sp. h. $= 9.1 \times 1.17 \times 0.2374 = 2.5276$ = heat taken from air.

Rise in temp. of water $1.89 \times 130.8589 = 247.3233$ = heat given to calorimeter.

2.5276 = heat taken from air.

244.7957 = heat dissipated in 2 hours.

Hourly dissipation of heat 122.3978

SUMMARY.

Hourly dissipation of heat before operation		132.0811
Hourly dissipation of heat after operation:	First period	109.9631
	Second period	122.3978
Loss of heat dissipation following operation:	*First period*	22.118
	Second period	9.6833

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in 2 hours 0.6, in 1 hour 0.3 = t.

$Q = W \times t \times$ sp. h. $= 14.5 \times 0.3 \times 0.75 = 3.2625$ = heat added to reserve.

132.0811 = hourly dissipation of heat.

3.2625 = hourly addition to heat reserve.

Hourly production of heat 135.3436

AFTER OPERATION.

1st Period—

Rise of bodily temperature in 1½ hours 0.2, in 1 hour 0.13 = t.

$Q = W \times t \times$ sp. h. $= 14.5 \times 0.13 \times 0.75 = 1.4137$ = heat added to reserve.

109.9631 = hourly dissipation of heat.

1.4137 = hourly addition to heat reserve.

Hourly production of heat 111.3768

2d Period—

Rise of bodily temperature in 2 hours 0.6, in 1 hour 0.3 = t.

$Q = W \times t \times$ sp. h. $= 14.5 \times 0.3 \times 0.75 = 3.2625$ = heat added to reserve.

122.3978 = hourly dissipation of heat.

3.2625 = hourly addition to heat reserve.

Hourly production of heat 125.6603

SUMMARY.

Hourly production of heat before operation		135.3436
Hourly production of heat after operation:	First period	111.3768
	Second period	125.6603
Loss of heat production following operation:	*First period*	23.9668
	Second period	9.6833

Experiment 85.

A dog. Weight 14 pounds.

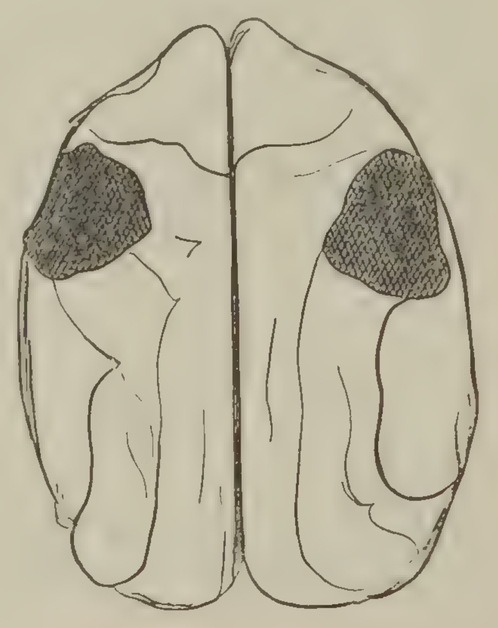
June 10.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:27 A. M.	62°.96	68°	65°.192	103°	840.5
11:42	62.96	67.8			
11:57	64.76	67.8			
12:12 P. M.	65.12	67.8			
12:27	65.39	68			
12:42	65.36	67.69			
12:57	65.21	68			
1:12	65.66	67.79			
1:27	65.21	68			
1:42	65.75	68.27			
1:57	.....	.....	68.216	103.6	1003.
	64.84 (mean)	67.91	3.024 (gain)	0.6 (gain)	162.5
		64.84			
		3.07 (gain)			

2:20 P. M.—Temperature of the hind paw 99°. 2:30 P. M.—Both sides of brain operated on with white hot iron. 2:50 P. M.—Rectal temperature 102°.2.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box. Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:2 P. M.	.....	.....	67°.796	.....	1067
3:17	62°.77	69°.95			
3:32	64.76	70.06			
3:47	65.66	69.95			
4:2	65.75	71.24			
4:17	65.6	71.06			
4:32	65.75	70.97			
4:47	65.96	70.88			
5:2	.....	.....	69.71	102°.20	1196
	65.18 (mean)	70.59	1.914 (gain)		129
		65.18			
		5.41 (gain)			

Fig. 8.



Jan. 11. Temperature of right hind paw 93°.6; left paw lower than my thermometer will register; no distinct loss of tactile sense. Animal killed.

Autopsy.—Two very large wounds: one on the right side about a half inch posterior to the sulcus cruciatus, involving the second and third convolutions, barely touching the extreme outer part of first. On the left side a similar wound, so situated that its border comes to within a quarter of an inch of the extreme outer end of the sulcus cruciatus. Both wounds reaching to the ventricles.

Heat Dissipation.

Before Operation.

Quantity of air (V′) = 162.5 at 67°.91 — 32° = 35.91 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{162.5}{1.07} = 152$. $W = V \times 0.08073 = 12.3$

Rise in temp. of air 3.07 = t. $Q = W \times t \times$ sp. h. $= 12.3 \times 3.07 \times 0.2374 = 8.9645$ = heat given to air.

Rise in temp. of water $3.024 \times 130.859 = 395.7176$ = heat given to calorimeter.

8.9645 = heat given to air.

404.6821 = heat dissipation in $2\frac{1}{2}$ hours.

Hourly dissipation of heat 161.8728

AFTER OPERATION.

Quantity of air (V′) = 129 at 70°.58 — 32° = 38.58 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{129.}{1.079} = 110.3$. $W = V \times 0.08073 = 8.9$

Rise in temp. of air 5.41 = t. $Q = W \times t \times$ sp. h. $= 8.9 \times 5.41 \times 0.2374 = 11.4318$ = heat given to air.

Rise in temp. of water $1.914 \times 130.859 = 250.4641$ = heat given to calorimeter.

11.4318 = heat given to air.

261.8959 = heat dissipated in 2 hours.

Hourly dissipation of heat 130.9479

SUMMARY.

Hourly dissipation before operation	161.8728
Hourly dissipation after operation	130.9479
Loss of heat dissipation following operation	30.9249

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in 2 hours 0°.6, in 1 hour 0.3 = t.

$Q = W \times t \times$ sp. h. $= 14 \times 0.3 \times 0.75 = 3.15$ = heat added to reserve.

161.8728 = hourly dissipation of heat.

Hourly production of heat 165.0228

AFTER OPERATION.

No change in bodily temperature.

Hourly heat dissipation = *hourly heat production* 130.9479

SUMMARY.

Hourly production of heat before operation	165.0228
Hourly production of heat after operation	130.9479
Loss in hourly heat production following operation	34.0749

EXPERIMENT 86.

A small black and tan terrier. Weight 8.3 pounds.

June 12.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:58 P. M.	.....	.....	63°.05	102°.4	684
1	61°	66°.8			
1:15	63.04	66.8			
1:30	65.12	66.8			
1:45	65.48	66.92			
2	65.39	67.01			
2:15	65.39	67.01			
2:28	.....	.....	64.76	102.8	797
	64.22 (mean)	66.89	1.71 (gain)	0.4 (gain)	113
		64.22			
		2.67 (gain)			

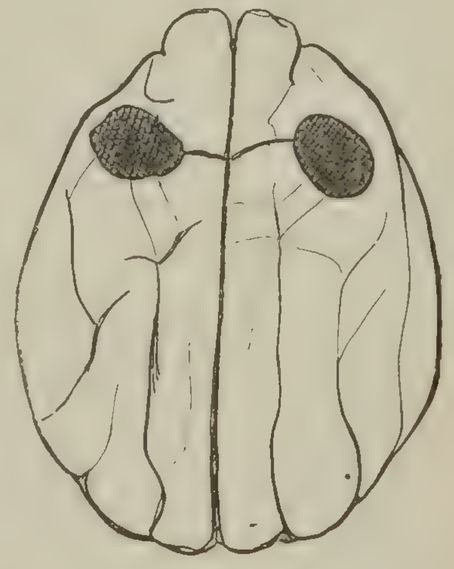
2:45 P. M.—Brain operated on; centres mechanically destroyed.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:28 P. M.	.....	.....	65°.48	101°.3	801
3:50	63°.8	68°.36			
4:5	64.76	68.27			
4:20	64.88	68.18			
4:35	65.3	68.18			
4:50	65.84	68.9			
5:8	.....	.....	67.568	101.5	930
	64.92 (mean)	68.38	2.088 (gain)	0.2 (gain)	129
		64.92			
		3.46 (gain)			

June 13.—Tactile sense completely abolished in all the paws.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
1:10 P. M.	.....	.....	63°.338	101°.5	541.2
1:15	66°.08	68°.48			
2:30	67.88	68.27			
1:45	67.76	68.6			
2	68.24	68.81			
2:15	69.53	69.35			
2:30	69.44	69.44			
2:45	70.25	70.16			
3:10	.....	.....	66.14	99.5	669.5
	68.45 (mean)	69.01	2.802 (gain)	2 (loss)	128.3
		68.45			
		0.56 (gain)			

Fig. 9.



Autopsy.—Right side: wound involving the sulcus cruciatus in whole of second convolution, and also involving to some extent first and third convolutions, extending down into ventricles. Left side: a similar wound situated somewhat nearer the middle line, so as to involve very largely the first convolution.

Heat Dissipation.

Before Operation.

Quantity of air (V′) = 113 at 66°.89 — 32° = 34.89 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{113}{1.071} = 105.5$. $W = V \times 0.08073 = 8.52$

Rise in temp. of air 2.67 = t. $Q = W \times t \times$ sp. h. $= 8.52 \times 2.67 \times 0.2374 = 5.4005$ = heat given to air.

Rise in temp. of water $1.71 \times 79.5436 = 136.0195$ = heat given to calorimeter.

5.4005 = heat given to air.

141.42 = heat dissipated in 1½ hours.

Hourly dissipation of heat 94.28

AFTER OPERATION

Quantity of air (V) = 129 at 68°.38 — 32° = 36.38 = t′. $V + (V \times t' \times 0.002035) = V'$.

$V = \frac{129}{1.074} = 120$. $W = V \times 0.08073 = 9.7$

Rise in temp of air 3.46 = t. $Q = W \times t \times$ sp. h. $= 3.46 \times 0.2374 \times 0.75 = 0.6161$ = heat given to air.

Rise in temp. of water $2.088 \times 79.5436 = 166.087$ = heat given to calorimeter.

0.6161 = heat given to air.

166.7031 = heat dissipated in 1½ hours.

Hourly dissipation of heat 111.1354

Second Period—

Quantity of air (V′) = 128.3 at 69°.01 — 32° = 37.01 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{128.3}{1.075} = 119.3$. $W = V \times 0.08073 = 9.63$

Rise in temp. of air 0.56 = t. $Q = W \times t \times$ sp. h. $= 9.63 \times 0.56 \times 0.2374 = 1.2802$ = heat given to air.

Rise in temp. of water $2.802 \times 79.5436 = 222.8812$ = heat given to calorimeter.

1.2802 = heat given to air.

224.1614 = heat dissipated in 2 hours.

Hourly dissipation of heat 112.0807

SUMMARY.

Hourly heat dissipation before operation		94.28
Hourly heat dissipation after operation :	First period	111.1354
	Second period	112.0807

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in 1½ hours 0°.4, in 1 hour 0.2666 = t.

$Q = W \times t \times$ sp. h. $= 8.3 \times 0.2666 \times 0.75 = 1.66$ = heat added hourly to reserve.

94.28 = hourly dissipation of heat.

1.66 = hourly addition to reserve.

Hourly heat production 95.94

AFTER OPERATION.

First Period—

Rise of bodily temperature in 1½ hours 0°.2, in 1 hour 0.1333 = t.

$Q = W \times t \times$ sp. h. $= 8.3 \times 0.1333 \times 0.75 = 0.83$ = heat added hourly to reserve.

111.1354 = hourly dissipation of heat.

0.83 = hourly addition to reserve.

Hourly heat production 111.9654

Second period—

Fall of bodily temperature in 2 hours 2°, in 1 hour 1= t.

$Q = W \times t \times$ sp. h. $= 8.3 \times 1 \times 0.75 = 6.225$ = heat lost from reserve.

112.0807 = heat dissipated hourly.

6.225 = heat hourly lost from reserve.

Hourly heat production 105.8557

SUMMARY.

Hourly heat production before operation		95.94
Hourly heat production after operation :	First period	111.9654
	Second period	105.8557
Gain in heat production following operation :	*First period*	16.0254
	Second period	9.9157

Experiment 87.

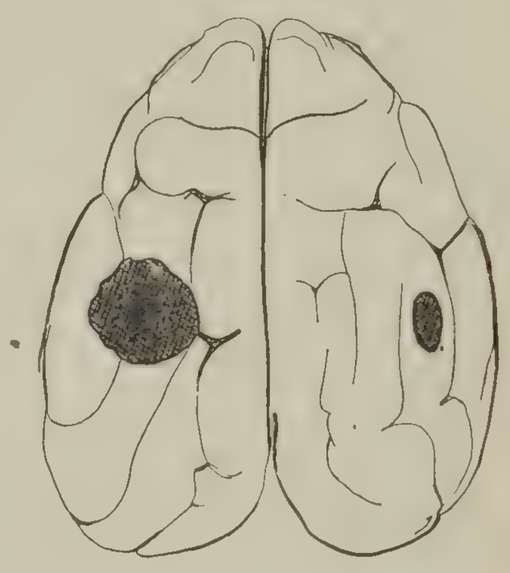
A cur. Weight 11.5 pounds.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:10 A. M.	.....	.....	65°.21	103°	123.5
11:25	67°.37	68°.6			
11:45	65.75	68.99			
12 M.	67.28	68.99			
12:15 P. M.	67.55	69.08			
12:30	67.76	69.26			
12:40	.....	.....	67.478	102.4	263
	67.14 (mean)	68.98 67.14	2.268 (gain)	0.6 (loss)	139.5
		1.84 (gain)			

1 P. M.—Brain operated on; mechanical destruction of cortex.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
2:18 P. M.	.....	.....	67°.664	101°.8	315.4
2:35	69°.62	70°.79			
2:45	69.71	71.48			
3	70.07	71.6			
3:15	70.34	71.87			
3:30	70.52	71.87			
3:48	.....	.....	69.665	104	460.2
	70.05 (mean)	71.52 70.05	2.001 (gain)	2.2 (gain)	144.8
		1.47 (gain)			

Fig. 10.



Autopsy.—Right wound of brain small, penetrating through the gray matter, involving only the third convolution near the posterior part of the middle third. Left wound large, involving both the second and third convolutions situated correspondingly to the other brain wound. (Fig. 10.)

Heat Dissipation.

Before Operation.

Quantity of air (V′) = 139.5 at 68°.98 — 32° = 36.98 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{139.5}{1.075} = 130$. $W = V \times 0.08073 = 10.5$

Rise in temp. of air 1.84 = t. $Q = W \times t \times$ sp. h. $= 10.5 \times 1.84 \times 0.2374 = 4.5866$ = heat given to air.

Rise in temp. of water $2.268 \times 79.5436 = 180.4049$ = heat given to calorimeter.

4.5866 = heat given to air.

184.9915 = heat dissipated in $1\frac{1}{2}$ hours.

Hourly dissipation of heat 123.3277

AFTER OPERATION.

Quantity of air (V′) = 144.8 at 71°.52 − 32° = 39.52 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{144.8}{1.08} = 134$. $W = V \times 0.08073 = 10.8$

Rise in temp. of air = 1.47 = t. $Q = W \times t \times$ sp. h. = 10.8 × 1.47 × 0.2374 = 3.7689 = heat given to air.

Rise in temp. of water 2.001 × 79.5436 = 159.1667 = heat given to calorimeter.

3.7689 = heat given to air.

162.9356 = heat dissipated in 1½ hours.

Hourly dissipation of heat 108.6237

SUMMARY.

Hourly dissipation of heat before operation	123.3277
Hourly dissipation of heat after operation	108.6237
Hourly loss of heat dissipation following operation	14.704

Heat Production.

BEFORE OPERATION.

Fall of bodily temperature in 1½ hours 0°.6, in 1 hour 0.4 = t.

Q = W × t × sp. h. = 11.5 × 0.4 × 0.75 = 3.45 = heat lost from reserve.

123.3277 = hourly dissipation of heat.

3.45 = hourly loss from heat reserve.

Hourly production of heat 119.8777

AFTER OPERATION.

Rise of bodily temperature in 1½ hours 2°.2, in 1 hour 1.4667 = t.

Q = W × t × sp. h. = 11.5 × 1.4667 × 0.75 = 12.65 = heat added to reserve.

108.6237 = hourly dissipation of heat.

12.65 = hourly addition to heat reserve.

Hourly production of heat 121.2737

SUMMARY.

Hourly production of heat after operation	121.2737
Hourly production of heat before operation	119.8777
Hourly gain of heat production after operation	1.396

EXPERIMENT 88.

A cur. Weight 32.75 pounds.

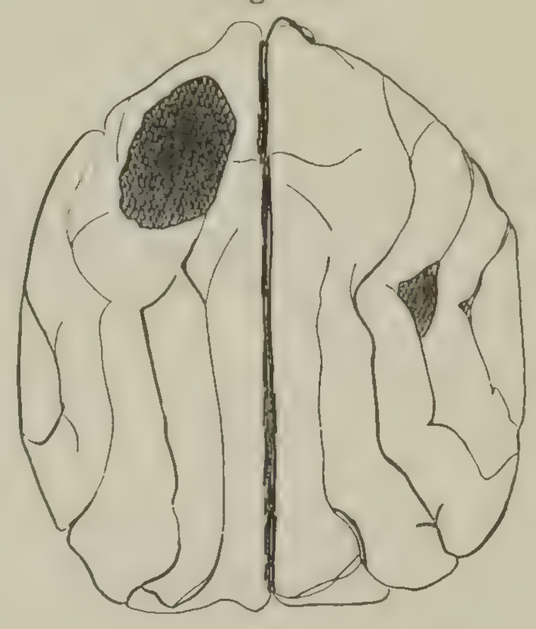
June 17.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:40 P. M.	.....	.....	68°.99	102°.4	420
12:45	73°.52	74°.21			
1	73.94	73.55			
1:15	74.48	73.55			
1:30	74.6	73.35			
1:45	75.02	74.12			
2	75.74	74.21			
2:15	74.39	74.48			
2:30	75.83	74.84			
2:40	.....	.....	71.645	102	536.6
	74.69 (mean)	74.04 74.69	2.655 (gain)	0.4 (loss)	116.6
		0.65 (loss)			

3 P. M.—Brain operated on mechanically.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:40 P. M.	.....	.....	71°.6	101°.1	560
4	74°.3	76°.01			
4:15	74.39	76.28			
4:30	75.11	76.37			
4:45	75.32	76.64			
5	75.44	76.82			
5:15	75.44	76.82			
5:30	75.44	76.82			
5:46	.....	.....	74.12	102.8	674
	75.06 (mean)	76.54	2.52 (gain)	1.7 (gain)	114
		1.48 (gain)			

Fig. 11.



Autopsy.—Wound of left cerebrum very large and very deep, involving first, second, and third convolutions, in the region of the sulcus cruciatus. Wound of right cerebrum small, extending through the gray matter and involving the third and fourth convolutions situated antero-posteriorly near the centre of the brain.

Heat Dissipation.

Before Operation.

Quantity of air (V′) = 116.6 at 74°.04 — 32° = 42.04 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{116.6}{1.085} = 107.5$. $W = V \times 0.08073 = 8.68$

Fall in temp. of air 0.65 = t. $Q = W \times t \times$ sp. h. $= 8.68 \times 0.65 \times 0.2374 = 1.3394$ = heat taken from air.

Rise in temp. of water $2.655 \times 130.8589 = 347.4304$ = heat given to calorimeter.

1.3394 = heat taken from air.

346.091 = heat dissipated in 2 hours.

Hourly dissipation of heat 173.0455

After Operation.

Quantity of air (V′) = 114 at 76°.54 — 32° = 44.54 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{114}{1.09} = 104.6$. $W = V \times 0.08073 = 8.44$

Rise in temp. of air 1.48 = t. $Q = W \times t \times$ sp. h. $= 8.44 \times 1.48 \times 0.2374 = 2.9654$ = heat given to air.

Rise in temp. of water $2.52 \times 130.8589 = 329.7644$ = heat given to calorimeter.

2.9654 = heat given to air.

332.7298 = heat dissipated in 2 hours.

Hourly dissipation of heat 166.3649

Heat Production.

Before Operation.

Fall of bodily temperature in 2 hours 0°.4, in one hour 0.2 = t.

$Q = W \times t \times$ sp. h. $= 32.75 \times 0.2 \times 0.75 = 4.9125$ = heat taken from reserve.

173.0455 = hourly dissipation of heat.

4.9125 = heat taken from reserve.

Hourly production of heat. 168.133

AFTER OPERATION.

Rise of bodily temperature in 2 hours 1°.7, in one hour 0.85 = t.

Q = W × t × sp. h. = 32.75 × 0.85 × 0.75 = 20.8781 = heat added to reserve.

166.3649 = heat dissipation in an hour.
20.8781 = heat added to reserve.

Hourly production of heat 187.243

SUMMARY.

Hourly production of heat after operation	187.243
Hourly production of heat before operation	168.133
Hourly gain of heat production following operation	19.11

EXPERIMENT 89.

A cur. Weight 20 pounds.

June 20, 12:50 P. M.—Rectal temperature 103°.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:12 P. M.	.....	.....	67°.76	1021
1:20	73°.19	70°.64		
1:35	73.85	70.97		
1:50	74.48	71.6		
2:5	73.94	71.42		
2:20	74.6	71.72		
2:40	.....	.....	68.81	1291
	74.01	71.27	1.05	270
	71.27	(mean)	(gain)	
	2.74 (loss)			

2:50 P. M.—Rectal temperature 103°.

3 P. M.—Brain operated on mechanically; violent hemorrhage, stopped by plugging the orifice.

3:40 P. M.—Rectal temperature 102°.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:45 P. M.	.....	.....	69°.416	266
4	73°.94	70°.06		
4:15	76.37	72.59		
4:30	76.16	72.77		
4:45	76.04	72.42		
5	75.44	72.5		
5:15	.....	.....	70.268	438
	75.59	72.07	0.852	172
	72.07	(mean)	(gain)	
	3.52 (loss)			

5:25 P. M.—Rectal temperature 102°.4.

Autopsy, June 21.—Very large hernia cerebri. On opening the skull: the left hemisphere with its surface destroyed over the anterior third, everywhere through the gray matter, and much of the space throughout almost the whole depth. Right hemisphere; a large deep wound extending anteriorly nearly to the extreme outer part of the sulcus cruciatus, involving the second and third convolutions. Base of the brain and all the furrows of the upper surface filled with dense hard blood clots.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V′) = 270 at 71°.27 — 32° = 39.27 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{270}{1.08} = 250$. $W = V \times 0.08073 = 20.2$

Fall in temp. of air 2.74 = t. $Q = W \times t \times$ sp. h. $= 20.2 \times 2.74 \times 0.2374 = 13.14$ = heat taken from air.

Rise in temp. of water $1.05 \times 130.8589 = 137.4018$ = heat given to calorimeter.

13.14 = heat taken from air.

124.2618 = heat dissipated in 1½ hours.

Hourly dissipation of heat 82.8412

AFTER OPERATION.

Quantity of air (V′) = 172 at 72°.07 — 32° = 40.07 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{172}{1.082} = 159$. $W = V \times 0.08073 = 12.84$.

Fall in temp. of air 3.52 = t. $Q = W \times t \times$ sp. h. $= 12.84 \times 3.52 \times 0.2374 = 10.7345$ = heat taken from air.

Rise in temp. of water $0.852 \times 130.8589 = 111.4918$ = heat given to calorimeter.

10.7345 = heat taken from air.

100.7573 = heat dissipated in 1½ hours.

Hourly dissipation of heat 67.1716

SUMMARY.

Hourly dissipation of heat before operation	82.8412
Hourly dissipation of heat after operation	67.1716
Hourly loss of heat dissipation following operation	15.6696

Heat Production.

BEFORE OPERATION.

No change of bodily temperature, hourly dissipation = *hourly production of heat* 82.8412.

AFTER OPERATION.

Rise of bodily temperature in 1½ hours 0°.4, in 1 hour 0.2667 = t.

$Q = W \times t \times$ sp. h. $= 20 \times 0.2667 \times 0.75 = 4$ = heat added to reserve.

67.1716 = hourly dissipation of heat.

4 = hourly addition to heat reserve.

Hourly production of heat 71.1716

SUMMARY.

Hourly production of heat before operation	82.8412
Hourly production of heat after operation	71.1716
Hourly loss of heat production following operation	11.6696

EXPERIMENT 90.

A dog. Weight 10 pounds.

11:25 A. M.—Rectal temperature 102°.2.

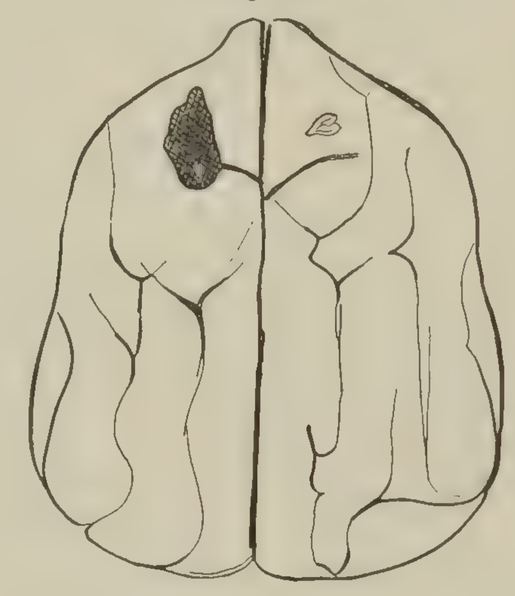
TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:32 A. M.	.....	.....	66°.902	708
11:40	70°.88	71°.96		
11:55	71.51	71.96		
12:10 P. M.	71.87	72.41		
12:32	.....	.....	68.342	804
	71.42 (mean)	72.11	1.44 (gain)	96
		71.42		
		0.69 (gain)		

12:40 P. M.—Rectal temperature 102°.10. 12:50 P. M.—Brain operated on.
2:46 P. M.—Rectal temperature 102°.4.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:56 P. M.	.....	.....	69°.44	810.2
3:3	74°.72	74°.84		
3:18	75.2	75.2		
3:28	75.02	75.08		
3:45	74.84	75.47		
3:50	.....	.....	71.161	918
	74.94 (mean)	74.94	1.721 (gain)	97.8
		0.21 (gain)		

4 P. M.—Rectal temperature 102°.

Fig. 12.



Autopsy.—Large wound involving the second and third convolutions in the neighborhood of the sulcus cruciatus. Least possible scratch on the anterior left hemisphere, some distance in front of sulcus cruciatus.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V′) = 96 at 72°.11 — 32° = 40.11 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{96}{1.08} = 89$. $W = V \times 0.08073 = 7.18$

Rise in temp. of air 0.69 = t. $Q = W \times t \times$ sp. h. $= 7.18 \times 0.69 \times 0.2374 = 1.1761$ = heat given to air.
Rise in temp. of water $1.44 \times 79.5436 = 114.5434$ = heat given to calorimeter.

1.1761 = heat given to air.

Hourly dissipation of heat 115.7195

AFTER OPERATION.

Quantity of air (V′) = 97.8 at 75°.15 — 32° = 43.15 = t′.

$V + (V \times t \times 0.002035) = V'$. $V = \frac{97.8}{1.087} = 90$. $W = V \times 0.08073 = 7.26$.

Rise in temp. of air 0.21 = t. $Q = W \times t \times$ sp. h. $= 7.26 \times 0.21 \times 0.2374 = 0.3619$ = heat given to air.
Rise in temp. of water $1.721 \times 79.5436 = 136.8952$ = heat given to calorimeter.

0.3619 = heat given to air.

Hourly dissipation of heat 137.2571

SUMMARY.

Hourly dissipation of heat before operation 115.7195
Hourly dissipation of heat after operation 137.2571

Hourly loss of heat dissipation following operation 21.5376

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in an hour 0.1 = t.
$Q = W \times t \times$ sp. h. $= 10 \times 0.1 \times 0.75 =$ 0.75 = heat added to reserve.
115.7195 = heat dissipation in an hour.

Hourly production of heat 116.4695

After Operation.

Fall of bodily temperature in $1\frac{1}{4}$ hours 0.4, in 1 hour 0.32 = t.

Q = W × t′ × sp. h. = 10 × 0.32 × 0.75 =	2.4	= heat taken from reserve.
	137.2571	= heat dissipated hourly.
Heat produced hourly	134.8571	

Summary.

Hourly production of heat before operation	116.4695
Hourly production of heat after operation	134.8571
Hourly increase of heat production following operation	18.3876

Experiment 91.

A bitch. Weight 20.75 pounds.

June 26. 11:20 A. M.—Rectal temperature 102°.5.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:30 A. M.	.....	.....	72°.37	102°.5	136
11:50	75°.92	74°.3			
12:5 P. M.	75.65	74.84			
12:20	75.74	74.75			
12:30	.....	.....	73.04	.....	242
	75.77	74.63	0.67		106
	74.63	(mean)	(gain)		
	1.14 (loss)				

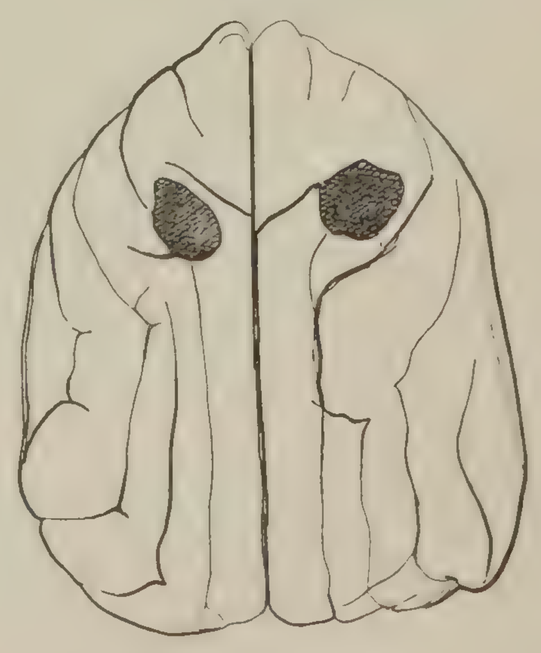
12:40 P. M.—Rectal temperature 102°.5. 12:50 P. M.—Brain exposed. 3:10 P. M.—Burning of Hitzig's region with hot iron, both sides.

3:25 P. M.—Rectal temperature 101°.4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:37 P. M.	.....	.....	74°.12	.....	438
3:52	79°.76	77°.36			
4:7	80.12	77.45			
4:22	79.76	77.54			
4:37	79.76	77.54	75.12	.....	531.2
	79.85	77.47	1		93.2
	77.47	(mean)	(gain)		
	2.38 (loss)				

4:45 P. M.—Rectal temperature 102°.6.

Fig. 13.



Autopsy.—Extensive wound of the first convolution on each side of the brain just posterior to the sulcus cruciatus. (Fig. 13.)

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V′) = 106 at 74°.63 — 32° = 42.63 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{106}{1.087} = 97.5$. $W = V \times 0.08073 = 7.89$.

Rise in temp. of air 1.14 = t. $Q = W \times t \times$ sp. h. $= 7.89 \times 1.14 \times 0.2374 = 2.1354$ = heat taken from air.

Rise in temp. of water $0.67 \times 130.8589 = 87.6755$ = heat given to calorimeter.

2.1354 = heat taken from air.

Hourly dissipation of heat 85.5401

AFTER OPERATION.

Quantity of air (V′) = 93.2 at 77°.47 — 32° = 45°.47 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{93.2}{1.092} = 85.4$. $W = V \times 0.08073 = 6.9$

Fall in temp. of air 2.38 = t. $Q = W \times t \times$ sp. h. $= 6.9 \times 2.38 \times 0.2374 = 3.8986$ = heat taken from air.

Rise in temp. of water $1 \times 130.8589 = 130.8589$ = heat given to calorimeter.

3.8986 = heat taken from air.

Hourly dissipation of heat 126.9603

SUMMARY.

Hourly dissipation of heat before operation	85.5401
Hourly dissipation of heat after operation	126.9603
Hourly gain in heat dissipation following operation	41.4202

Heat Production.

BEFORE OPERATION.

No change in bodily temperature.

Heat dissipated hourly = *heat produced hourly* 85.5401.

AFTER OPERATION.

Rise of bodily temperature in $1\frac{1}{3}$ hour 1°.2, in 1 hour 0.9 = t.

$Q = W \times t \times$ sp. h. $= 20.75 \times 0.9 \times 0.75 = 14.0062$ = heat added to reserve.

126.9603 = heat dissipated hourly.

Hourly heat production 140.9665

SUMMARY.

Heat produced hourly before operation	85.5401
Heat produced hourly after operation	140.9665
Hourly gain in heat production following operation	55.4264

EXPERIMENT 92.

A bitch. Weight 11.2 pounds.

June 26, 11:30 A. M.—Rectal temperature 103°.5.

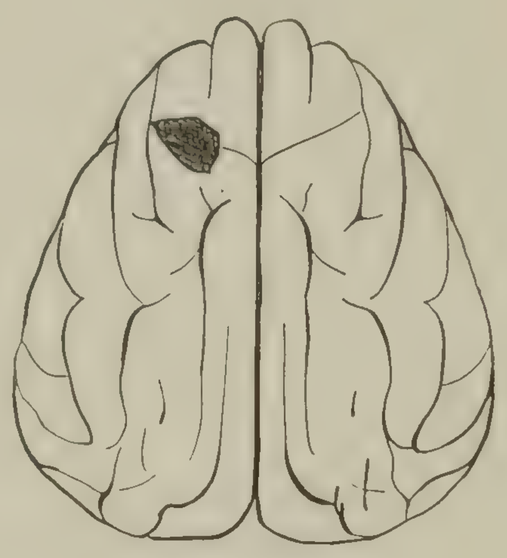
TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:40 A. M.	.....	.....	71°.16	910
11:50	75°.92	76°.4		
12:5 P. M.	75.65	76.52		
12:20	75.74	76.52		
12:40	76.04	77.12		
12:55	76.72	77.24		
1:10	77.18	77.45	72.784	1029
	76.21 (mean)	76.87	1.624 (gain)	119
		76.21		
		0.66 (gain		

1:15 P. M.—Rectal temperature 102°.4.
1:20 P. M.—Brain exposed. 2 P. M.—Brain wounded mechanically on one side.
2:5 P. M.—Rectal temperature 101°.2.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:13 P. M.	.....	.....	73°.10	1035
2:30	77°.63	79°.07		
2:45	78.44	79.07		
3:30	79.43	80		
3:43	.....	.....	74.93	1150
	78.5 (mean)	79.38	1.83 (gain)	115
		78.5		
		0.88 (gain)		

2:50 P. M.—Rectal temperature 102°.6.

Fig. 14.



Autopsy.—Only one side of the brain injured. Wound passing through the gray matter, involving the first and second convolutions anterior and posterior to the sulcus cruciatus.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V′) = 119 at 76°.87 — 32° = 44.87 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{119}{1.09} = 109$. $W = V \times 0.08073 = 8.8$

Rise in temp. of air 0.66 = t. $Q = W \times t \times$ sp. h. $= 0.66 \times 8.8 \times 0.2374 = 1.3788$ = heat given to air.
Rise in temp. of water $1.624 \times 79.5436 = 129.1794$ = heat given to calorimeter.

1.3788 = heat given to air.

130.5582 = heat dissipated in 1½ hours
Hourly dissipation of heat 87.0388

AFTER OPERATION.

Quantity of air (V′) = 115 at 79°.38 — 32° = 47.38 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{115}{1.096} = 105$. $W = V \times 0.08073 = 8.5$

Rise in temp. of air 0.88 = t. $Q = W \times t \times$ sp. h. $= 8.5 \times 0.88 \times 0.2374 = 1.7757$ = heat given to air.
Rise in temp. of water $1.83 \times 79.5436 = 145.5655$ = heat given to calorimeter.

1.7757 = heat given to air.

147.3412 = heat dissipated in 1½ hours.
Hourly dissipation of heat 98.2275

SUMMARY.

Hourly dissipation of heat before operation	87.0388
Hourly dissipation of heat after operation	98.2275
Hourly gain of heat dissipation following operation	11.1887

Heat Production.

BEFORE OPERATION.

Fall of bodily temperature in $1\frac{3}{4}$ hours 1°.1, in 1 hour 0.6286 = t.
Q = W × t × sp. h. = 11.2 × 0.6286 × 0.75 = 5.2802 = hourly loss from heat reserve.

87.0388 = hourly dissipation of heat.
5.2802 = loss from heat reserve.

Hourly production of heat 81.7586

AFTER OPERATION.

Rise of bodily temperature in $1\frac{3}{4}$ hours 1°.4, in 1 hour 0.8 = t.
Q = W × t × sp. h. = 11.2 × 0.8 × 0.75 = 6.72 = heat added to reserve.

6.72 = hourly addition to heat reserve.
98.2275 = hourly heat dissipation.

Hourly production of heat 104.9475

SUMMARY.

Hourly production of heat before operation	81.7586
Hourly production of heat after operation	104.9475
Hourly gain of heat production following operation	23.1889

EXPERIMENT 93.

A dog. Weight 15 pounds.
12 M.—Rectal temperature 105°.

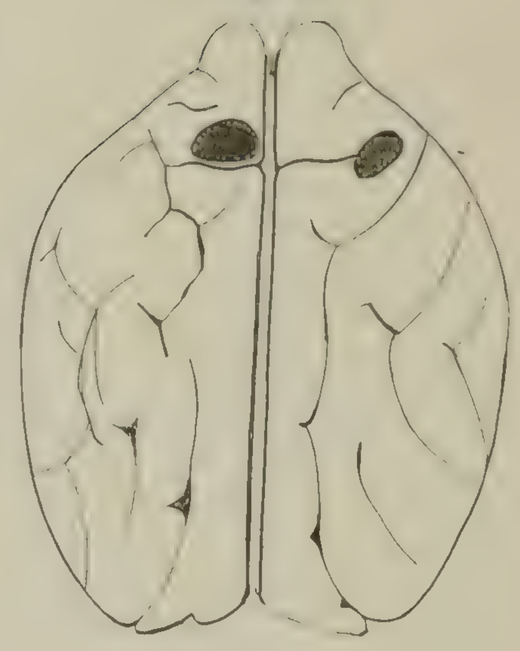
TIME.	AIR TEMP. (Fah.)	TUBE TEMP (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:12 P. M.	64°.67	64°.94	60°.03	692
12:27	64.76	65.30		
12:42	67.16	67.28		
12:57	65.48	66.68		
1:12	64.76	66.68		
1:27	65.6	67.01		
1:42	65.3	67.37		
1:57	64.67	67.55		
2:12	64.22	68.09		
2:27	64.13	68.36		
2:42	64.13	68.36		
2:57	63.80	68		
3:12	66.08	68.60	65.03	835.5
	64.98 (mean)	67.25 64.98	5 (gain)	143.5 (gain)
		2.27 (gain)		

3:20 P. M.—Rectal temperature 105°. 3:30 P. M.—Operated on.
4:4 P. M.—Rectal temperature 102°.8.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
4:20 P. M.	65°.72	66°.29	63°.25	883
4:35	65.94	66.56		
4:50	64.58	66.68		
5:5	65.39	67.19		
5:20	66.08	67.46		
5:35	67.76	67.64		
5:50	68.81	68.09	65.30	952
	66.32 (mean)	67.13 66.32	2.05 (gain)	69
		0.81 (gain)		

6:4 P. M.—Rectal temperature 103°.8. Dog killed.

Fig. 15.



Autopsy.—Wound of the left hemisphere: immediately in front of the sulcus cruciatus, not wounding the gray matter of the first convolution posterior to the sulcus at all, or the white matter below it, just scraping the front of the sulcus. Right hemisphere: the gray matter at the distal end of the sulcus, and beyond it destroyed.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V′) = 143.5 at 67°.25 — 32° = 35.25 = t.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{143.5}{1.072} = 133.8$. $W = V \times 0.08073 = 10.8$

Rise in temp. of air 2.27 = t. $Q = W \times t \times$ sp. h. = $10.8 \times 2.27 \times 0.2374 = 5.8201$ = heat given to air.

Rise in temp. of water $5 \times 130.8589 = 654.2945$ = heat given to calorimeter.

5.8201 = heat given to air.

660.1146 = heat dissipated in 3 hours.

Hourly dissipation of heat 220.0382

AFTER OPERATION.

Quantity of air (V′) = 69 at 67°.13 — 32° = 35.13 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{69}{1.071} = 64.4$. $W = V \times 0.08073 = 5.2$

Rise in temp. of air 0.81 = t′. $Q = W \times t \times$ sp. h. = $5.2 \times 0.81 \times 0.2374 = 0.9999$ = heat given to air.

Rise in temp. of water $2.05 \times 130.8589 = 268.2607$ = heat given to calorimeter.

0.9999 = heat given to air.

269.2606 = heat dissipated in $1\frac{1}{2}$ hours.

Hourly dissipation of heat 179.5071

SUMMARY.

Hourly dissipation of heat before operation	220.0382
Hourly dissipation of heat after operation	179.5071
Hourly loss of heat dissipation following operation	40.5311

Heat Production.

BEFORE OPERATION.

No change of temperature of body.

Hourly dissipation = *hourly production of heat* 220.0382

AFTER OPERATION.

Rise of bodily temperature in 1 hour 0.5 = t.

$Q = W \times t \times$ sp. h. = $15 \times 0.5 \times 0.75 =$ 5.625 = heat added to reserve.

179.5071 = hourly dissipation of heat.

Hourly production of heat 185.1321

SUMMARY

Hourly production of heat before operation	220.0382
Hourly production of heat after operation	185.1321
Hourly loss of heat production following operation	34.9061

Experiment 94.

A long-haired Scotch terrier. Weight 13.5 pounds.

0:30 A. M.—Rectal temperature, 103°.7.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
10:53 A. M.	69°.92	69°.56	64°.4	462.5
11:8	66.38	67.76		
11:23	65.81	67.28		
11:38	65.81	67.28		
11:53	66.56	67.28		
12:8 P. M.	66.68	67.64		
12:23	66.8	67.76		
12:38	66.92	67.37		
12:53	67.04	67.76		
1:8	67.28	68.36		
1:23	67.55	68.48	66.22	594.5
	66.89 (mean)	67.87	1.82 (gain)	132 (gain)
		66.89		
		0.98 (gain)		

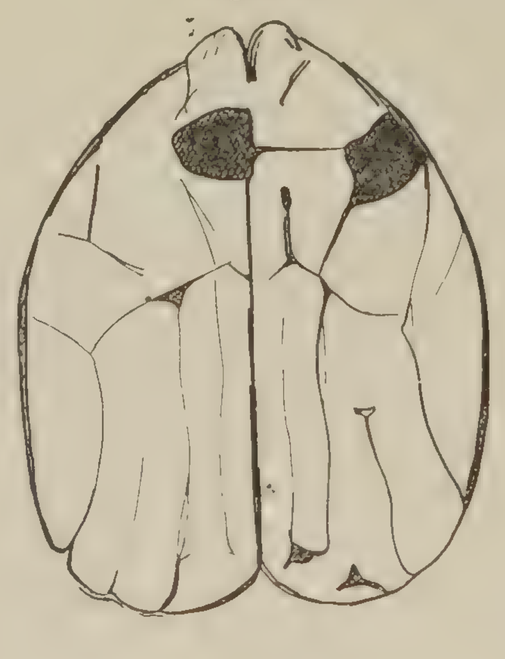
1:30 P. M.—Rectal temperature, 103°.9 1:45 P. M.—Operation.

2:42 P. M.—Rectal temperature, 102°.7.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
2:58 P. M.	69°.98	69°.08	65°.03	540.5
3:13	70.04	68.98		
3:28	69.92	69.08		
3:43	69.62	69.2		
3:58	69.32	69.2		
4:13	69.32	69.32		
4:28	68.36	69.32		
4:43	70.28	69.89		
4:58	71.78	69.89		
5:13	73.13	70.43		
5:28	73.22	71.87	67.09	661
	70.45	69 66 (mean)	2.06 (gain)	120.5 (gain)
	69.66			
	0.79 (loss)			

5:42 P. M.—Rectal temperature 102°.9.

Fig. 16.



Autopsy.—Brain: Left side, first convolution destroyed at the sulcus cruciatus. Right side, second convolution destroyed in similar situation; first convolution slightly wounded.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V′) = 132 at 67°.87 — 32° = 35.87 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{132}{1.073} = 123$. $W = V \times 0.08073 = 9.93$.

Rise in temp. of air 0.98 = t. $Q = W \times t \times$ sp. h. $= 9.93 \times 0.98 \times 0.2374 = 2.3102$ = heat given to air.

Rise in temp. of water $1.82 \times 130.858 = 238.1616$ = heat given to calorimeter.

2.3102 = heat given to air.

240.4718 = heat dissipated in 2½ hours.

Hourly dissipation of heat 96.1487

AFTER OPERATION.

Quantity of air (V′) = 120.5 at 69°.66 — 32° = 37.66 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{120.5}{1.077} = 112$. $W = V \times 0.08073 = 9.04$

Fall in temp. of air 0.79 = t. $Q = W \times t \times 0.2374 = 1.6954$ = heat taken from reserve.

Rise in temp. of water $2.06 \times 130.858 = 269.5675$ = heat given to calorimeter.

1.6954 = heat taken from air.

267.8721 = heat dissipated in 2½ hours.

Hourly dissipation of heat 107.1488

SUMMARY.

Hourly dissipation of heat after operation	107.1488
Hourly dissipation of heat before operation	96.1487
Gain in hourly heat dissipation following operation	11.0001

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in 3 hours 0°.2, in 1 hour 0.066 = t.

$Q = W \times t \times$ sp. h. $= 13.5 \times 0.066 \times 0.75 = 0.668$ = heat added hourly to reserve.

96.1487 = hourly dissipation of heat.

0.668 = heat added to reserve hourly.

Hourly heat production 96.8167

AFTER OPERATION.

Rise of bodily temperature in 3 hours 0°.2, in 1 hour 0.066 = t.

$Q = W \times t \times$ sp. h. $= 13.5 \times 0.066 \times 0.75 = 0.668$ = heat added to reserve.

0.668 = hourly addition of heat to reserve.

107.1488 = hourly dissipation of heat.

Hourly production of heat 107.8168

SUMMARY.

Hourly heat production after operation	107.8168
Hourly heat production before operation	96.8167
Hourly gain of heat production after operation	11.0001

Experiment 95.

A terrier. Weight 14 pounds.

November 25, 1:45 P. M.—Rectal temperature 103°.4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)	Remarks.
1:59 P. M.	68°.36	69°.32	59°.9	319.25	
2:14	64.04	66.68			
2:29	64.31	65.21			
2:44	66.47	66.47			
2:59	65	66.08			
3:14	64.58	65.6			
3:29	64.13	65.48			
3:44	65.39	66.08			
3:59	66.47	66.38			
4:14	65.96	66.56	.....	.....	Dog quiet throughout experiment.
4:29	65.72	67.1			
4:44	64.88	68.18			
4:59	65.72	67.55	63.41	438.5	
	65.46 (mean)	66.67	3.51 (gain)	119.25	
		65.46			
		1.21 (gain)			

5:15 P. M.—Rectal temperature 104°.1.

5:45 P. M.—Dog operated on. 6:10 P. M.—Rectal temperature 104°.93.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)	Remarks.
6:13 P. M.	62°.6	65°.96	60°.35	463.75	Dog quiet.
6:28	63.32	66.8	.....	.....	Dog quiet.
6:43	64.31	66.92	.....	.....	Dog whining.
6:58	65.72	67.28	.....	.....	Dog quiet.
7:13	65.39	67.64	.....	.....	Dog restless.
7.28	65.6	68.27	.....	.....	Dog quiet.
7:43	64.4	67.55	.....	.....	Dog quiet.
8:5	66.47	68.09	.....	.....	Dog quiet.
8:13	.....	.....	63.7	568.2	Dog quiet.
	64.73 (mean)	67.31	3.35 (gain)	104.45	
		64.73			
		2.58 (gain)			

8:25 P. M.—Rectal temperature 102°.8.

9 P. M.—Rectal temperature 102°.8.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)	Remarks.
9:13 P. M.	68°.9	67°.01	61°.72	614	Dog quiet.
9:35	58.7	64.52	.....	.....	Dog quiet.
9:53	64.76	65.21	.....	.....	Dog quiet.
10:13	65.48	66.08	.....	.....	Dog howling.
10:35	64.40	66.08	.....	.....	Dog howling.
10:55	64.67	66.29	.....	.....	Dog quiet.
11:15	62.1	66.29	.....	.....	Dog quiet.
11:35	61.9	65.21	.....	.....	Dog quiet.
12:13	.....	.....	64.13	897.65	Dog quiet.
	63.86 (mean)	65.83	2.41 (gain)	283.65	
		63.86			
		1.97 (gain)			

November 26, 12:30 A. M.—Rectal temperature 102°.5.

1:30 A. M.—Rectal temperature 102°.8.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)	Remarks.
2:18 A. M.	69°.8	68°.09	64°.13	920	Dog quiet.
2:45	70.64	69.56	.....	.....	Dog quiet.
3:5	60.3	65.6	.....	.....	Dog howling.
3:25	69.2	68.48	.....	.....	Dog howling.
3:38	69.86	68.98	.....	.....	Dog quiet.
4	67.04	67.88	.....	.....	Dog quiet.
4:18	.....	.....	65.23	1078	Dog quiet.
	67.81 (mean)	68.1 67.81	1.1 (gain)	158	
		0.29 (gain)			

4:30 A. M.—Rectal temperature 102°.5.

6:43 A. M.—Rectal temperature 103°.3.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)	Remarks.
7:3 A. M.	68°.36	67°.46	64°.22	227	
7:18	67.64	67.76			
7:33	66.47	68.09			
7:48	67.16	68.18			
8:3	67.28	68.27			
8:18	66.92	68.18			
8:33	66.8	68.27			
8:48	66.68	68.18			
9:3	67.76	68.27	65.39	323	
	67.23 (mean)	68.07 67.23	1.17 (gain)	96	
		0.84 (gain)			

9:13 A. M.—Rectal temperature 102°.9.

Heat Dissipation.

Before Operation.

Quantity of air (V′) = 119.25 at 66°.67 — 32° = 34.67 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{119.25}{1.07} = 111.45$. $W = V \times 0.08073 = 9$

Rise in temp. of air 1.21 = t. $Q = W \times t \times$ sp. h. $= 9 \times 1.21 \times 0.2374 = 2.5853$ = heat given to air.

Rise in temp. of water $3.51 \times 130.8589 = 459.3147$ = heat given to calorimeter.

2.5853 = heat given to air.

461.9 = heat dissipated in 3 hours.

Hourly dissipation of heat 153.63

After Operation.

First Period—

Quantity of air (V′) = 104.45 at 67°.31 — 32° = 35.31 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{104.45}{1.072} = 97.44$. $W = V \times 0.08073 = 7.866$

Rise in temp. of air 2.58 = t. $Q = W \times t \times$ sp. h. $= 7.866 \times 2.58 \times 0.2374 = 4.8179$ = heat given to air.

Rise in temp. of water $3.35 \times 130.8589 = 438.3773$ = heat given to calorimeter.

4.8179 = heat given to air.

443.1952 = heat dissipated in 2 hours.

Hourly dissipation of heat 221.5976

Second Period—

Quantity of air (V′) = 283.65 at 65°.83 — 32° = 33.83 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{283.65}{1.069} = 265.34$. $W = V \times 0.08073 = 2.14$

Rise in temp. of air 1.97 = t. $Q = W \times t \times$ sp. h. = $2.14 \times 1.97 \times 0.2374 = 10.0083$ = heat given to air.
Rise in temp. of water $2.41 \times 130.8589 = 315.3726$ = heat given to calorimeter.
10.0083 = heat given to air.

325.3809 = heat dissipated in 3 hours.

Hourly dissipation of heat 108.4603

Third Period–

Quantity of air (V′) = 158 at 68°.1 — 32° = 36.1 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{158}{1.073} = 147.2$. $W = V \times 0.08073 = 11.9$

Rise in temp. of air 0.29 = t. $Q = W \times t \times$ sp. h. = $11.9 \times 0.29 \times 0.2374 = 0.8193$ = heat given to air.
Rise in temp. of water $1.1 \times 130.8589 = 143.9448$ = heat given to calorimeter.
0.8193 = heat given to air.

144.7641 = heat dissipated in 2 hours.

Hourly dissipation of heat 72.382

Fourth Period—

Quantity of air (V′) = 96 at 68°.07 — 32° = 36.07 = t′.

$V + (V \times t' \times 0.002035) = V$. $V = \frac{96}{1.073} = 89.4$. $W = V \times 0.08073 = 7.2$

Rise in temp. of air 0.84 = t. $Q = W \times t \times$ sp. h. = $7.2 \times 0.84 \times 0.2374 = 1.4357$ = heat given to air.
Rise in temp. of water $1.17 \times 130.8589 = 153.1049$ = heat given to calorimeter.
1.4357 = heat given to air.

154.5406 = heat dissipated in 2 hours.

Hourly dissipation of heat 77.2703

SUMMARY.

Hourly dissipation of heat before operation		153.63
Hourly dissipation of heat after operation:	First period	221.5976
	Second period	108.4603
	Third period	72.382
	Fourth period	77.2703
Gain of hourly dissipation of heat after operation:	*First period*	67.9676
Loss of hourly dissipation of heat after operation:	*Second period*	45.1697
	Third period	81.248
	Fourth period	76.3597

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in 1 hour 0.2 = t.
$Q = W \times t \times$ sp. h. = $14 \times 0.2 \times 0.75 = 2.1$ = heat added to reserve.
153.63 = hourly dissipation of heat.
2.1 = hourly addition to heat reserve.

Hourly production of heat 155.73

AFTER OPERATION.

First Period—

Fall of bodily temperature in 1 hour 0°.8 = t.
$Q = W \times t \times$ sp. h. = $14 \times 0.8 \times 0.75 = 8.4$ = heat taken from reserve.
221.5976 = hourly dissipation of heat.
8.4 = hourly loss from heat reserve.

Hourly production of heat 230.044

18 July, 1880.

Second Period—

Fall of bodily temperature in 1 hour 0.086 = t.
Q = W × t × sp. h. = 14 × 0.086 × 0.75 = 0.903 = heat taken from reserve.

108.4603	= hourly dissipation of heat.
0.903	= hourly loss from heat reserve.
Hourly production of heat 107.5573	

Third Period—

Fall of bodily temperature in 1 hour 0.1 = t.
Q = W × t × sp. h. = 14 × 0.1 × 0.75 = 1.05 = heat taken from reserve.

72.382	= hourly dissipation of heat.
1.05	= hourly loss from heat reserve.
Hourly production of heat 71.332	

Fourth Period—

Fall of bodily temperature in 1 hour 0.18 = t.
Q = W × t × sp. h. = 14 × 0.18 × 0.75 = 1.89 = heat taken from reserve.

77.2703	= hourly dissipation of heat.
1.89	= hourly loss from heat reserve.
Hourly production of heat 75.3803	

SUMMARY.

Hourly production of heat before operation		155.73
Hourly production of heat after operation:	First period	230.044
	Second period	107.5573
	Third period	71.332
	Fourth period	75.3803
Gain of hourly production of heat after operation:	*First period*	74.314
Loss of hourly production of heat after operation:	*Second period*	48.1727
	Third period	84.398
	Fourth period	80.3497

In studying the results of these experiments the comparison is most readily made by means of tabulated statements. Of these three are appended: the first, including experiments in which both first convolutions were involved; the second, cases in which only one first convolution was involved; third, experiments in which other portions of the brain were alone wounded. The figures given under the headings of first day and second day express the hourly rate of heat production.

TABLE I.—BOTH FIRST CONVOLUTIONS INVOLVED.

Exp.	First Day.		Second Day.		Remarks.
	Before Operation.	After Operation.	First Period.	Second Period.	
76	89.5104	120.7453	83.2849	90.0946	
80	74.3056	129.3578			
82	160.0696	217.592			
86	95.94	111.9654	105.8557	.....	Wounds very deep and large, so as to make much shock.
91	85.5401	140.9665			
95	155.73	230.044	107.5573	.....	Periods follow one another, 71.332–75.3803

TABLE II.—ONE FIRST CONVOLUTION INVOLVED.

EXP.	FIRST DAY.		SECOND DAY.		REMARKS.
	Before Operation.	After Operation.	First Period.	Second Period.	
78	51.9827	.....	78.0282		
79	146.3214	161.5229	119.2054	.....	Left Hitzig's destroyed; also corpus callosum.
81	73.1349	89.1422	91.4658	100.2661	The only wound of brain was so far back as scarcely to be in Hitzig's region.
88	168.133	187.243			
89	82.8412	71.1716	.....	.....	A great deal of bleeding with brain-clots all over base, may account for different results.
90	116.4695	134.8571			
92	81.7586	104.9475			
94	96.8167	107.8168			

TABLE III.—WOUNDS NOT INVOLVING FIRST CONVOLUTION.

EXP.	FIRST DAY.		SECOND DAY.		REMARKS.
	Before Operation.	After Operation.	Before Operation.	After Operation.	
77	51.616	47.9833	67.7586		
83	118.4111	95.2983			
84	135.3436	111.3768	125.6603		
85	165.0228	130.9479			
87	119.8777	121.2737			
93	220.0382	185.1321			

In looking over these tables it will be seen that there are fourteen experiments in which one or both of the first convolutions were injured immediately behind the sulcus cruciatus, and six experiments in which other portions of the brain were alone affected. In not one of the latter was there any increase of heat production worthy of notice immed ately following the brain injury, whilst in thirteen of the fourteen experiments, compromitting the so-called "Hitzig's region," there was a decided increase in the yield of heat. In the exceptional experiment a large sinus was wounded, and the blood clotting upon all parts of the brain must have greatly disturbed all the results, affecting profoundly by pressure both the vaso-motor and respiratory functions; the exceptional result is therefore very well accounted for. Of the thirteen consonant experiments, in seven there was one, and in six there were both of the first convolutions injured. In the latter set, the increase of heat production was, reading the experiments as they are arranged in the table, about 35, 74, 36, 27, 65, and 47 per cent.; in the experiments in which only one centre was injured, the increased production of heat was, reading as before, but omitting the first experiment because no study was made after the operation until the next day, 10, 22, 11, 15, 30, and 12 per cent. The average increase in the heat production was therefore 47 per cent. when both sides of the brain were affected, and 17 per cent. when only one side was compromitted. When to this relation is added the fact that in twenty experiments the results were uniform, except in one instance in which the brain was deluged with blood from a wounded sinus, it is difficult to resist believing that in the dog *destruction of the brain region known as the first cerebral convolution posterior to and in the vicinity of the sulcus cruciatus is followed by an increase in heat production.* It may be noted that in several of the experiments, in which other portions of the brain than Hitzig's region were destroyed, there was a very decided fall in the rate of heat production.

A plausible explanation of this fall is to be found in the supposition that in these instances the wounds of the brain were sufficiently near the Hitzig's region to irritate it. In order to determine whether such irritation would diminish heat production, two experiments were performed. A properly located opening was made in the skull of the dog by a trephine, and the brain membranes carefully dissected off: the orifice was then filled with salt, which was held in its place by a pledget of lint, over which the scalp wound was closed by sewing. The experiments are as follows:—

Experiment 96.

A dog. Weight 22 pounds. 11:20 A. M.—Rectal temperature 102°.5.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:32 A. M.	.....	.....	70°.34	492
12:45	72°.42	73°.04		
12 M.	73.3	73.04		
12:15 P. M.	73.64	72.5		
12:32	73.94	73.14	71.42	604
	73.32	72.93	1.08	112
	72.93	(mean)	(gain)	
	0.39 (loss)			

12:45 P. M.—Rectal temperature 102°.5. 1 P. M.—Brain exposed. 1:55 P. M.—Dry salt put on Hitzig's regions.

2 P. M.—Rectal temperature 102°.4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
2:16 P. M.	74°.72	74°.57	71°.69	615
2:35	74.02	74.66		
2:50	75.56	75.08		
3:5	76.16	74.75		
3:20	76.16	75.29		
3:35	75.92	74.57	72.905	750
	75.42	74.82	1.215	135
	74.82	(mean)	(gain)	
	0.6 (loss)			

4 P. M.—Rectal temperature 102°.6.

Autopsy.—The regions salted comprised the first and second convolutions of each hemisphere for some distance on both sides of the sulcus cruciatus; arachnoid much injected.

Heat Dissipation.

Before Irritation.

Quantity of air (V′) = 112 at 72.93° − 32° = 40.93 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{112}{1.083} = 103.4$. $W = V \times 0.08073 = 8.35$

Fall in temp. of air 0.39 = t. $Q = W \times t \times$ sp. h. $= 8.35 \times 0.39 \times 0.2374 = 0.7731$ = heat taken from air.

Rise in temp. of water $1.08 \times 130.8589 = 141.3276$ = heat given to calorimeter.

0.7731 = heat taken from air.

Heat dissipated in one hour 140.5545

After Irritation.

Quantity of air (V′) = 135 at 74°.82 — 32° = 42.82 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{135}{1.087} = 124.2$. $W = V \times 0.08073 = 10.03$

Fall in temp. of air 0.6 = t. $Q = W \times t \times$ sp. h. $= 10.03 \times 0.6 \times 0.2374 = 1.4287$ = heat taken from air.

Rise in temp. of water $1.215 \times 130.8589 = 158.9936$ = heat given to calorimeter.

1.4287 = heat taken from air.

157.5649 = heat dissipated in 1½ hours.

Hourly dissipation of heat 105.0433

Summary.

Heat dissipated before irritation	140.5545
Heat dissipated after irritation	105.0433
Hourly loss of heat dissipation following irritation	35.5112

Heat Production.

Before Irritation.

No change of bodily temperature.

Heat dissipated in an hour = *hourly production of heat* 140.5545

After Irritation.

Rise of bodily temperature in 2 hours 0°.2, in 1 hour 0.1 = t.

$Q = W \times t \times$ sp. h. $= 22 \times 0.1 \times 0.75 = 1.65$ = heat added in an hour to reserve.

105.0433 = heat dissipated in an hour.

Hourly production of heat 106.6933

Summary.

Hourly heat production before irritation	140.5545
Hourly heat production after irritation	106.6933
Hourly diminution of heat production following irritation	33.8612

Experiment 97.

A bitch. Weight 20.5 pounds. 11 A. M.—Rectal temperature 103°.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:16 A. M.	.....	.....	67°.46	104°.8	784.3
11:40	70°.88	71°.51			
11:55	71.51	73.24			
12:10 P. M.	71.87	73.45			
12:16	.....	.....	69.32	104.8	886.6
	71.42 (mean)	72.73	1.86 (gain)		102.3
		71.42			
		1.31 (gain)			

12:25 P. M —Rectal temperature 103°. 1 P. M.—Brain exposed; on opening brain trephine slipped into brain.

2 P. M.—Salt put on the brain. 2:25 P. M.—Rectal temperature 104°.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
2:32 P. M.	.....	.....	70°.88	905.4
2:48	74°.84	74°.21		
3:3	74.72	74.48		
3:18	75.2	74.48		
3:28	75.02	74.57	72.26	984
	74.95	74.43 (mean)	1.38 (gain)	78.6
	74.43			
	0.52 (loss)			

3:40 P. M.—Rectal temperature 104°.8. 3:43 P. M.—Hitzig's region destroyed with a knife.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:55 P. M.	.....	.....	72°.5	1008
4:10	75°.44	76°.28		
4:25	76.04	76.16		
4:55	76.16	77.36	74.21	1111.45
	75.88 (mean)	76.6	1.71 (gain)	103.45
		75.88		
		0.72 (gain)		

5 P. M.—Rectal temperature 104°.

Autopsy.—Extreme right anterior lobe of brain cut to pieces; wound not extending to within one-quarter inch of sulcus cruciatus. Small wound of second and third convolution in sulcus of left side, extending to ventricle.

Heat Dissipation.

Before Irritation.

Quantity of air (V′) = 102.3 at 72°.73 — 32° = 40.73 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{102.3}{1.086} = 94.4$. $W = V \times 0.08073 = 7.62$

Rise in temp. of air 1.31 = t. $Q = W \times t \times$ sp. h. $= 7.62 \times 1.31 \times 0.2374 = 2.3698$ = heat given to air.
Rise in temp. of water $1.86 \times 130.8589 = 243.3975$ = heat given to calorimeter.
2.3698 = heat given to air.

Hourly dissipation of heat 245.7673

After Irritation.

First Period—

Quantity of air (V′) = 78.6 at 74°.43 — 32° = 42.43 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{78.6}{1.086} = 72.3$. $W = V \times 0.08073 = 5.84$

Fall in temp. of air 0.52 = t. $Q = W \times t \times$ sp. h. $= 0.52 \times 5.84 \times 0.2374 = 0.7209$ = heat taken from air.
Rise in temp. of water $1.38 \times 130.8589 = 180.5852$ = heat given to calorimeter.
0.7209 = heat taken from air.

Hourly dissipation of heat 179.8643

Second Period—

Quantity of air (V′) = 103.45 at 76°.6 — 32° = 44.6 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{103.45}{1.09} = 95$. $W = V \times 0.08073 = 7.67$

Rise in temp. of air 0.72 = t. $Q = W \times t \times$ sp h. $= 7.67 \times 0.72 \times 0.2374 = 1.3110$ = heat given to air.
Rise in temp. of water $1.71 \times 130.8589 = 223.7687$ = heat given to calorimeter.
1.3110 = heat given to air.

Hourly dissipation of heat 225.0797

Summary.

Hourly dissipation of heat before irritation		245.7673
Hourly dissipation of heat after irritation:	First period	179.8643
	Second period	225.0797

Heat Production.

Before Irritation.

No change of bodily temperature.
Hourly dissipation = *hourly production of heat* 245.7673

AFTER IRRITATION.

First Period—

Rise of temperature of body in $1\frac{1}{4}$ hours 0°.8, in 1 hour 0°.64 = t'.

Q = W × t' × sp. h. = 20.5 × 0.64 × 0.75 = 9.84 = heat added to reserve.

179.8643 = heat dissipated hourly.

Hourly production of heat 189.7043

Second Period—

Fall of temperature in $1\frac{1}{3}$ hours 0°.8, in 1 hour 0°.6 = t'.

Q = W × t' × sp. h. = 20.5 × 0.6 × 0.75 = 9.225 = heat taken from reserve.

225.0797 = heat hourly dissipated.

9.225 = heat taken from reserve.

Hourly production of heat 215.8547

SUMMARY.

Hourly production before irritation	245.7673
Hourly production during irritation	189.7043
Hourly production after destruction	215.8547

The first of these experiments is a simple one, performed in the manner already indicated. It will be noted that during the period of irritation there was a decided reduction in the hourly production of heat amounting to 22 per cent. In the second experiment the diminution in the rate of heat production following the salting was curiously enough also 22 per cent. There was in the second experiment an attempt to destroy the centres after the period of irritation; neither of them, however, was destroyed. The rise of heat production that followed the operation was distinct, but did not equal the previous fall, the whole amount of heat produced not being as great as before the skull was opened. Probably there was in this case during the last calorimetrical observation paresis of one centre, and irritation of the other.

The experiments which have just been detailed are in accord with those previously reported, in which the brain was locally destroyed. The results of the entire series, comprising 22 consecutive concordant experiments, are summed up in the following proposition:—

Destruction of the first cerebral convolution in the dog posterior to and in the vicinity of the sulcus cruciatus is followed at once by a very decided increase of heat production, whilst after irritation of the same nervous tract there is a decided decrease of heat production.

Whatever may be the exact nature of the proven relation between the region of the brain under discussion and thermogenesis, there is one very important point which is not absolutely determined by my experiments, namely, as to the permanency of the effects induced. There are three experiments bearing upon the subject, in which only one convolution was wounded; in two of these trials the increase of heat production was seemingly maintained twenty-four hours after the operation, but in the third it was not kept up. There are also three experiments in which the two centres were involved; in only one of these is there any show of permanency in the increased heat production. In the most thoroughly watched of the experiments the early formation of an intra-ventricular clot may have

been the cause of the sudden check of heat production. Further elaborate experimentation can alone determine positively how permanent the influence of the brain region noted upon heat production is, but the drift of the evidence at present is to indicate that the effect is temporary, and that the first convolution does not contain the centres which preside over calorification, but is in some way connected with these centres so as to exert an influence upon them.

The probabilities are that the calorific centres are situated in the pons, and that the power of the first convolution depends upon habitual co-action. Thus, volition may habitually use the upper cortex spoken of in starting the machinery of muscular movement, and along with this machinery, or even as a necessary part of it, that of heat production may also be moved.

The conclusion just reached is in a measure related to the vexed question of cerebral localization. It may therefore be allowable to speak of the matter in a little more detail. All of the functions of the nervous centres are, in some of the lower forms of life, concentrated in a single cell, and as the scale of life is ascended the nervous system becomes more and more complex by the differentiation of its parts for the more complete performance of functional acts. It is evident that anatomical and functional differentiation must have at least some relation with one another, and that finally one act must be performed solely by one part. It seems inconceivable that a complex mechanism like the human cerebro-spinal axis should work harmoniously in any other way than that certain parts should perform certain acts. This localization of function it will be seen is not the result of an original rigid formation of the mechanism, but is probably acquired by habitual use for the species, and certainly also to some extent for the individual. All parts of the nervous system possess theoretically at least more or less of the original power which resided in the primordial nerve cell, and enabled it to perform various diverse acts. It is consequently perfectly conceivable that when one cell is disabled in the more complex mechanism another should gradually take on its function: Every physiologist who believes in a respiratory or a vaso-motor centre, if logical, believes also in the principle underlying cerebral localization. With the view of the matter just put forth it is evident that degrees of localization must exist. In the dog the speech centre, so far as is known, is not differentiated; in man it is strictly so. In the same way in the dog the motor centres of the cortex cerebri seem to have reached only the stage of habitual action, so that when one part of a convolution is removed another can replace it, whilst in the man the motor functions of the cortex appear to be differentiated beyond the stage of habitual action, and one part to be no longer able to replace another: consequently destructions which produce only evanescent results in the dog cause in the man permanent paralyses.

Having found that there is an apparent connection between the cerebral cortex and the thermic functions of the body, I have attempted to discover whether light could be thrown upon the truth or falsity of the theories of heat regulation heretofore discussed. It will be remembered that the conclusion was reached that there is either a general vaso-motor centre for the muscular system, situated above the medulla, which acts independently of the medullary vaso-motor centres, or else that there is in the pons or above it an inhibitory heat centre. It is hardly pos-

sible that the action of the cortical centres upon thermogenesis is merely that of a local vaso-motor influence; the action must involve the whole muscular system, and it would seem probable that it should be able to make itself perceived by an effect upon the blood pressure. To determine whether the vaso-motor system of the muscles is capable of modifying arterial pressure at all, the following experiments were performed. In them a curarized dog, with splanchnics and pneumogastrics cut, had his sciatic nerve irritated by a faradic current. Section of the splanchnics is believed to cause complete vaso-motor palsy of the abdominal vessels, and the question was whether after such palsy the contraction of the remaining arterioles of the body produced by irritating a sensitive nerve would be able to make an impression upon the arterial pressure.

Experiment 98.

A dog. Curari given; artificial respiration; pneumogastrics cut; left splanchnic (as shown by autopsy) completely severed above the diaphragm; right splanchnic divided except a corner of the sheath with possibly some nerve fibres remaining in it; sciatic nerve exposed.

Time. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	Remarks.
0	30	.....	
1	30	Current applied.	
4	37	.....	
6	44	.....	
12	52	.....	
15	53	.....	
18	52	Current broken.	
22	40	.....	Fig. 4, Plate IV, represents the tracing of this Experiment; I represents the point at which the circuit was closed; O, that at which it was broken.
30	37	.....	
36	29	.....	

Experiment 99.

A dog. Curari given; artificial respiration; par vagum divided; sciatic nerve exposed. Wound of the brain: right side, the first convolution, outer part of the sulcus cruciatus; left side, wound entirely in advance of the left sulcus cruciatus.

Time. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	Remarks.
0	45–35	Current applied.	
2	82–62	.....	Disturbance of respiration very marked, but no struggles.
4	78–58	.....	
14	68–55	Current broken.	
21	45–37	.....	

More curari given and splanchnics cut, as shown by the autopsy, just below the last rib.

Time. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	Remarks.
0	18	.....	
36	18	.....	Perfectly steady pressure since last note.
37	...	Current applied.	
41	20	.....	
43	21	.....	
46	23	.....	
49	24	.....	
53	26	.....	
56	29	.....	
60	28	.....	
64	28	Current broken.	
67	26	.....	
71	24	.....	
75	21	.....	

Time. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	Remarks.
0	18	.....	Pressure has been steady for many seconds.
1	...	Current applied.	
7	20	.....	
12	24	.....	
15	24	Current broken.	Pressure has been steady.
20	24	.....	
24	19	.....	

Experiment 100.

A dog. Par vagum cut; artificial respiration; woorari given; carotid artery used; splanchnics cut, as proved by autopsy, as they entered the crura of the diaphragm; sciatic exposed.

Time. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	Remarks.
0	28	.....	
2	28	Current applied.	
3	32	.....	
10	33	.....	
15	33	.....	
25	33	.....	
30	33	.....	
33	32	Current broken.	Fig. 3, Plate IV. represents the tracing of the arterial pressure.
36	29	.....	
33	27	.....	

Time. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	Remarks.
0	28	.....	
8	29	.....	
12	...	Current applied.	
15	35	.....	
22	36	.....	
28	42	.....	
37	42	Current broken.	Steady pressure since last note.
38	43	.....	
42	35	.....	
44	32	.....	

Time. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	Remarks.
0	27	Current applied.	
2	32	.....	

Experiment 101.

A dog. Curari given; artificial respiration; vagi divided; splanchnics cut just above the diaphragm, as shown by autopsy; sciatic nerve exposed. Some hemorrhage occurred during the operation and further lowered the blood pressure.

Time. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	REMARKS.
0	11	.....	
10	11	Current applied.	
15	15	.....	
20	20	.....	
25	26	.....	
30	24	.....	
35	24	Current broken.	
40	18	.....	
45	16	.....	
50	15	.....	
55	13	.....	

Time. Sec.	Arterial Pressure (Millimetres.)	Irritation.	REMARKS.
0	11	Current applied.	Fig. 1, Plate IV. represents the tracing of this Experiment.
5	17	.....	
10	20	.....	
30	24	.....	
40	26	Current broken.	
45	22	.....	
50	18	.....	
60	14	.....	

Detailed discussion of these experiments is not necessary; they prove that, although the influence of the splanchnics upon the force of the blood current is very great, after their section irritation of a sensitive nerve is still capable of producing a rise in the arterial pressure, and that consequently the arterioles, other than those of the abdomen, play at least some part in the determination of the blood pressure.

With this knowledge the next step in the investigation was to discover whether either irritation or destruction of the special region of the brain cortex, which is connected with the thermic functions of the body, has any influence upon the arterial pressure.

Experiment 102.

This dog had been used in the second fever experiment, but except for some embolic (?) lameness seemed well. Curari given; artificial respiration; femoral artery used; trephine opening upon each side over the Hitzig's centre; vagi not cut.

Time. H. M. Sec.	Arterial Pressure.*	REMARKS.
2:48 P.M.	215–220	
2:49	215–230	
2:49:10	215–225	Brain surface in Hitzig's regions mechanically destroyed.
2:49:20	205–220	

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* In the experiments marked with an asterisk, the scale of the instrument with which the pressures were taken was an arbitrary one; the numbers therefore represent units, whose exact value I am not now able to give. As each experiment is a relative one and complete in itself, this omission does not affect the conclusions to be drawn from the series.

Time. H. M. Sec.	Arterial Pressure.*	Remarks.
2:49:35	210–220	
2:49:50	215–225	
2:50	220–230	
2:50:15	215–235	
2:50:30	210–220	
2:50:50	220–230	Brain washed out very freely in mass.
2:51	215–225	
2:51:30	220–230	
2:52	215–225	
2:52:30	210–230	
2:53	215–225	
2:53:30	205–215	
2:55	210–220	Artificial respiration stopped.
	195–200	
2:56	200–210	Some respiratory movements.
	210–215	
2:57	220–225	No respiration.
2:58	227–50	
	227–50	Clot formed.
3	240–250	Clot cleaned out.
	255	
3: 1	255–260	
3: 1:30	245–250	Animal killed.

Autopsy.—The upper anterior third of the brain washed away so as to uncover freely the ventricles.

Experiment 103.

A dog. Artificial breathing, and curari used; a trephine opening over the sulcus cruciatus on each side.

Time. H. M. Sec.	Arterial Pressure.*	Remarks.
3:12 P. M.	230–240	
3:12:30	225–235	
3:13	230–240	Metallic wires connected with battery (Du Bois Reymond's apparatus, one large Grenet cell) inserted in immediate neighborhood of the sulcus cruciatus; mild current sent through.
3:13:5	220–230	
3:13:10	225–235	Muscular twitchings about the head very decided.
3:13:20	210–235	Current broken.
3:14	250	The full force of the coil applied; violent tetanus of the anterior part of the body.
3:14:30	235–245	Current broken.
3:15	220–235	
3:17	220–240	
3:18	210–225	
3:18:40	220–240	Mechanical destruction of the anterior part of the brain surface; general muscular movements induced.
3:19	210–260	
3:19:10	230–240	
3:19:20	240–250	
3:19:35	220–230	Animal quiet; voluntary breathing re-established.
3:19:50	220–235	
3:20	220–240	
3:20:10	210–230	
3:20:25	230–240	
3:20:35	220–240	
3:20:45	220–235	
3:21	210–225	A stream of water forced into the brain through one trephine opening, and out the other.
	200–210	

TIME. H. M. Sec.	ARTERIAL PRESSURE.*	REMARKS.
	210–230	
	220–230	
3:22	220–230	
	215–225	
	210–220	
	210–225	
3:23	210–220	

Autopsy.—Right side of brain: the whole region near the sulcus cruciatus washed away; the ventricles uncovered. Left side of brain: the same region gone excepting in its extreme outer portion.

In studying these experiments, it will be observed that they were performed upon dogs with the vagi uncut. In the first of the two, the Hitzig's region was destroyed mechanically without the arterial pressure being affected at all, it remaining steady from 215–230, rising and falling within narrow limits. One minute and forty seconds later, a strong stream of water was forced into one trephine opening and through to the other carrying out with it masses of brain. The effect of this procedure was remarkably little. There was no fall of the arterial pressure whatever for five minutes, and then the diminution was so slight and temporary that probably it had its source in some other cause than the operation. Some minutes later, artificial respiration being suspended, an enormous rise of the arterial pressure occurred, showing that the general vaso-motor system was intact.

In the second experiment, a mild electrical current sent through both Hitzig's regions produced no rise of pressure whatever. Later, a very powerful current produced a decided rise of pressure, to account for which, the violent tetanus of the anterior part of the body seemed itself sufficient. At 3:18:40 P. M., the surface of the Hitzig's cerebral region was mechanically destroyed. The muscular movements induced caused some momentary derangement of the circulation. In twenty seconds, however, the arterial pressure had returned to the place whence it started at 3:12 P. M., *i. e.*, from 225–240. It did not vary decisively from this until 3:21 P. M., when a stream of water was forced violently into the brain, producing great destruction. After this there was a very slight fall of pressure, the mercury descending to 210–230; a fall remarkably small considering the extent of the injury and the probability of the occurrence of severe shock.

It will be seen that these experiments are in accord, and warrant the following conclusion: that when the vagi are uncut, neither the application of galvanic currents to nor the mechanical destruction of Hitzig's region has any decided influence upon the blood pressure.

There was a distinct slowing of the pulse produced by the application of the galvanic current; which, of course, indicates an excitation of the pneumogastrics. Now, it is well known, that galvanization of a sensitive nerve in the dog with the vagi uncut often fails to induce rise of the arterial pressure—although it induces vaso-motor spasm—because it inhibits the cardiac action by stimulating the pneumogastric centres. As such an influence was manifest in the case under consideration, the following experiments were performed upon dogs with cut vagi:—

Experiment 104.

A very large dog. Curari given; artificial respiration; femoral artery used; par vagum cut; trephine opening on each side over Hitzig's region.

Time. H. M. Sec.		Arterial Pressure.*	Remarks.
11:18	A. M.	200–210	
11:19		200–210	
11:20		.....	A very strong faradic current sent through the brain, the wires being in the gray matter of Hitzig's regions.
11:20:15		200–240	General tetanus.
11:20:30		230–240	General tetanus.
11:21		225–235	General tetanus.
11:21:15		215–225	General tetanus.
11:21:20		.....	Current interrupted.
11:22		215–225	
11:23		.....	Animal lost about two fluidounces of blood.
11:23:45		.....	More curari given.
11:25		200–210	
11:25:15		205–215	
11:25:30		.....	A mild but decided current sent through the brain.
11:25:50		200–205	
11:26		.....	Very powerful current employed; no tetanus.
11:26:30		230–240	
11:26:45		225–230	Tracing Fig. 4, Plate II. represents the arterial pressure at the times marked thereon.
11:28:30		.....	Current interrupted.
11:29		215–225	
11:29:30		210–220	
11:30		200–220	
11:30:30		.....	Dura mater, etc., irritated by insertion of nozzle of syringe.
11:31:15		.....	Water forced in so as to destroy the brain.
11:31:30		350–400	
11:32		310	
11:32:15		280–310	
11:32:30		285–300	
11:33		285–300	
11:33:30		260–300	
11:34		280–290	
11:34:30		.....	Animal pithed. At the autopsy Hitzig's region found to have been destroyed upon both sides of the brain.

Experiment 105.

A moderate sized dog. Conditions as in the last Experiment, except that the vagi were not cut in the beginning of the Experiment.

Time. M.Sec.	Arterial Pressure.*	Remarks.
1:2	205–210	
1:25	205–210	
4:33	205–215	
5:40	200	A very decided current sent through the brain.
6	225–235	
6:12	235	General tremblings.
6:20	230	
6:30	220	Current broken.
7	.....	Vagi cut.
8	225–235	
8:5	215–230	
8:45	230–235	

TIME. M. Sec.	ARTERIAL PRESSURE.*	REMARKS.
9	250–260	Instrument plunged into the brain.
9:5	260–270	All this time the brain is being operated upon.
9:6	260–270	
9:10	270–280	
9:20	270–280	
9:26	230	
9:36	240	At this moment, water forced into the brain, washing out masses of it.
10	260–270	Work on brain ceased.
10:15	260–270	
10:30	250–260	
11	250–255	Animal pithed. At autopsy upper surface of the anterior lobes of the brain found disorganized.

EXPERIMENT 106.

A dog. Curari employed, with artificial respiration; femoral artery; two trephine openings made over the Hitzig's region, and galvanic needles inserted into the brain.

TIME. M. Sec.	ARTERIAL PRESSURE.*	REMARKS.
10	230–240	
10:20	240–250	
10:50	250–260	Weak current applied to the brain.
11	230–240	
11:15	240–250	
11:30	240–250	
11:40	.....	Current broken.
11:50	225–233	
13	230–235	
13:30	.....	Weak current applied to the brain.
13:40	230–235	
13:50	225–230	
14	.....	Current broken.
14:30	220–230	
15:35	220–225	

TIME. H. M. Sec.	ARTERIAL PRESSURE.*	REMARKS.
1:28:10 P. M.	210–215	
1:28:30	210–215	Weak current applied to the brain.
1:28:40	210–215	Fig. 3, Plate V. represents the tracing from 1:28:30 to 1:28:50.
1:28:50	.....	Current broken.
1:28:55	210–215	
1:29:30	210–220	Strong current to the brain. Fig. 6, Plate II. represents the tracing from 29:30 to 30.
1:29:50	220–225	Some struggles.
1:30	.....	Current broken. Fig. 5, Plate II. represents the tracing of arterial pressure needle from 1:31:45 to 1:32:10.
1:31:50	210–215	One side of the brain destroyed with a needle.
1:31:55	.....	Other side of the brain destroyed with a needle
1:32	210–215	
1:32:20	220	
1:32:40	210–225	
1:35	.....	Brain broken up afresh with the handle of a scalpel.
1:35:50	220–225	
1:36	220–225	
1:36:20	225–230	
1:37:10	220–225	
1:37:20	225–230	

Time. H. M. Sec.	Arterial Pressure.*	Remarks.
1:47:50	210–215	
1:48	210–215	
1:49	210–215	
1:50	200–210	
1:51	210–215	
1:52	210–215	Animal killed.

Autopsy.—Right and left side of the brain destroyed to the ventricles over a large surface involving the first, second, and third convolutions, and reaching to the sulcus cruciatus in front.

In the first of these experiments (Experiment 104) the very powerful current (the full force of the apparatus) applied in the beginning to the Hitzig's region, produced general tetanus with rise of the blood pressure. This was at 11:20 A. M. More curari having been given, sufficient to entirely paralyze voluntary movement, a mild current, but one sufficient to be very painful to the tongue, was applied to the brain at 11:25:30 A. M. This failed to produce rise of pressure, as is shown in the tracing Plate II. Fig. 4. This current was certainly sufficiently powerful to have violently affected the blood pressure, if it had been applied to a sensitive nerve. At 11:26 A. M. the current was increased to the full power of the coil, with the sudden rise of pressure, that is depicted in the tracing. Later on in the experiment, the nozzle of a syringe was forced into the brain, and a stream of water driven forcibly in. At once the blood pressure rose from 200–220 up to 350–400, and maintained itself at 280–290 for four minutes, till the lower brain was broken up with a pithing instrument.

In the next experiment (Experiment 105) a very decided current, sent through the brain before section of the vagi, caused an immediate rise of pressure, which may have been due to the general muscular tetanic tremblings. After the vagi were cut, the pressure stood at 230–235. When an instrument was plunged into one of the Hitzig's regions and the brain destroyed, the mercury at once rose to 250–260, and the brain being still worked with, the pressure was maintained for some seconds at 270–280; on ceasing the operation the mercury fell to 230. Water was now forced into the brain, bringing away large masses of it; the mercury immediately rose to 260 and 270, and although only ten or fifteen seconds were occupied with the process the pressure maintained itself at 250–255 for more than a minute, when the experiment was brought to an end.

The last experiment of the series (Experiment 106) is in accord with the others; a mild, but decided, faradic current applied to the Hitzig's region had no decided effect upon the blood pressure. This was tried three times; at 1:10:50, at 1:13:30, and at 1:28:30. At the first application there was apparently in the beginning a rise of pressure; but as this did not continue in this case, and did not occur at all in the other instances, it was probably due to some accidental extraneous momentary cause. A powerful current was applied to the brain at 1:29:30, and produced a slight rise, which may have been due to the violent struggles; this rise is seen in the tracing Plate II. Fig. 6. The lack of the effect in the final trial is well shown in the tracing Plate V. Fig. 3. Destruction of the Hitzig's region did not have as much effect as in the preceding experiment, but produced

at first some slight rise in the pressure, as is shown in the tracing (Plate II. Fig. 5). The arterial pressure was watched for nearly twenty minutes after the destruction of the brain and suffered no notable fall; showing that nothing comparable to a governing vaso-motor centre had been destroyed.

The experiments of the series are on the whole so closely concordant that further repetition has seemed unnecessary. They appear to establish the following conclusions: *After section of the vagi, in the curarized animal, mild irritation of the Hitzig's region has no influence upon the blood pressure;* but the application of powerful galvanic currents or of great mechanical violence produces a more or less marked elevation of the arterial pressure, which probably is due not to irritation of the Hitzig's region itself, but to irritation of the trigeminal nerve twigs in the dura mater, by diffusion of the electric current or of the excessive mechanical force.* *Total destruction of the Hitzig's region in both sides of the brain does not abate the blood pressure.*

The conclusions, just reached, would seem to show that neither irritation nor destruction of the first cerebral convolution in the dog is able distinctly to affect the arterial pressure when the par vagum is cut and the splanchnic nerves are entire.

Such experiments are however not entirely satisfactory. It is conceivable that a vaso-motor centre, controlling the bloodvessels in the muscles, may exist in the upper cerebrum and give no unmistakable sign of its presence when it is destroyed, because it is so overshadowed by the abdominal vaso-motor system; just as the addition of an individual dollar could not be perceived in a heap of coin. To sift the matter as closely as possible, several further series of experiments were undertaken. In the first of these, a sensitive nerve was galvanized, after section of the splanchnics and destruction of Hitzig's region in the cerebral cortex. It has already been shown that when the Hitzig's region is intact and the splanchnics are divided, galvanization of the sciatic causes a decided rise of the arterial pressure; now if this rise does not occur after destruction of the Hitzig's centre, such centre must obviously have a vaso-motor value; on the other hand, if the rise occur after as before the destruction of the cerebral cortex, the vaso-motor value of the latter must be null or exceedingly unimportant.

In the second series of experiments Hitzig's region was destroyed after section of the splanchnics, and the effect upon the arterial system noted.

If, after removal of the disturbing influence of the powerful abdominal circulation, the Hitzig's cortex is unable to sensibly influence the arterial pressure, *i. e.*, the vaso-motor condition of the extra-abdominal bloodvessels, the ascribing of a dominant vaso-motor power to it seems more than gratuitous. The experiments are as follows: —

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* I have frequently noted signs of extreme pain when working with brain membranes never any when the brain itself was alone disturbed.

20 July, 1880.

Experiment 107.

A dog. Morphia and curari employed, with artificial respiration; vagi cut; carotid and sciatic exposed; Hitzig's region destroyed.

Time. Sec.	Art. Press. (Millimetres.)	Irritation.	REMARKS.
0	38	Current applied.	The splanchnics not cut; arterial pressure has been steady some minutes; Faradic current used.
3	48		
5	58		
7	64		
10	71	.....	Tracing Fig. 1, Plate III.; the first + marks the beginning, the second + the ending of the irritation.
12	69	Current broken.	
14	63		
16	60		
19	56		
22	54		
28	46		

Splanchnics cut.

Time. Sec.	Art. Press. (Millimetres.)	Irritation.	REMARKS.
0	17	Current applied.	Arterial pressure has been steady for some time; Faradic current used.
3	19		
5	20		
9	22		
12	25		
14	28		
16	29		
21	29		
28	28	Current broken.	Fig. 2, Plate III.; I marks the beginning of irritation at 0 sec.,
32	24		the + the ending of irritation at 28 sec.
43	21		
49	20		
53	18		

Experiment 108.

A dog. Curari employed, with artificial respiration; pneumogastrics and splanchnics cut; skull opened, but brain not injured.

Time. M.Sec.	Art. Press. (Millimetres.)	Irritation.	REMARKS.
0	24–33		
0:6	32		
0:11	31		
0:25	30		
0:29	33		
0:38	33		
1	33	Current applied.	Strong Faradic current; no movements of the muscles tributary to
1:7	35		the nerve.
1:16	35		
1:25	35	Current broken.	The upper tracing, Fig. 3, Plate III., represents this experiment;
			the first cross belongs to the upper tracing, and marks 1 minute, when the irritation of the sciatic began.
1:34	35		Asphyxia produced.
1:42	45		Artificial respiration resumed. See Plate IV. Fig. 2.
1:50	35		
2	....	.....	Brain operated on, and Hitzig's region on both sides destroyed, as
4	29		was afterwards proven by the autopsy.
4:10	29		

Time. M. Sec.	Art. Press. (Millimetres.)	Irritation.	Remarks.
4:20	29	.....	
4:25	30	.....	
4:27	29	.....	
6	30	.....	
6:5	30	.....	
6:15	30	Current applied.	Faradic current of the same strength as previously employed.
6:20	34	.....	The lower tracing of Fig. 3, Plate III. represents the experiment,
6:22	35	.....	the second + belongs to it and marks the beginning of irritation.
6:28	38	.....	
6:32	40	.....	A kink in the tube of artificial respiration apparatus momentarily
6:34	45	.....	interfered with the supply of air, causing partial asphyxia.
6:39	38	.....	
6:49	35	Current broken.	
7:8	33	.....	Asphyxia produced.
7:10	42	.....	
7:20	44	.....	
7:22	44	.....	Animal killed.

In the first of these two experiments, the brain cortex having been destroyed mechanically and the par vagum cut, the arterial pressure rose, on galvanization of the sciatic nerve, from 38 to 69 millimetres. After section of the splanchnics the pressure rose from 17 to 29 millimetres on irritation of the sciatic, showing that destruction of the cerebral cortex and of the splanchnics does not produce complete vaso-motor palsy. The comparative effects of irritation before and after section of the splanchnics are well shown in Plate III., Figs. 1 and 2. The second experiment was even more conclusive in its evidence. The steady arterial pressure, after section of the splanchnics, was 31 to 33 millimetres. On galvanization of the sciatic it rose in seven seconds to 35, and on production of asphyxia to 45. The brain was then operated on, the Hitzig's cortex of both hemispheres being removed, and on one side the ventricles being freely opened. The arterial pressure at first fell to 29, but afterwards rose to 31. The sciatic was irritated with a Faradic current of the same strength as before, and in seven seconds the pressure rose to 35, and on asphyxia being induced increased still further to 45 (see Fig. 3, Plate III.). It is evident that in this case destruction of the cortex cerebri had no effect upon the arterial pressure after the removal of the dominant influence of the abdominal circulation, and it would seem as though vaso-motor influence must be excluded from the explanation of the effects of wounds of this portion of the cortex upon heat production.

The opinion has already been expressed that the centre which directly controls the production of animal heat is not in the cortex, consequently the fact that the cortex has no vaso-motor action whilst it indicates the truth of the theory of a direct nervous inhibition of heat production can hardly be considered to establish it. Not knowing exactly in what region of the brain the sought-for calorific centre, if it exists, is located, it is not possible to experiment directly upon the effects of its destruction, but plainly the direct facts can be indirectly discovered by studying the effect upon blood pressure of the galvanization of a sensitive nerve after section of the medulla at its junction with the pons and of the splanchnics, since such section removes the body from the influence of said calorific centre. The following experiment is in such direction.

Experiment 109.

A dog. The medulla cut; pneumogastric severed; artificial respiration employed; woorari administered; carotid artery and sciatic nerve used.

Time. M. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	Remarks.
0	50	.....	
10	50	Galvanic.	Strong Faradic current.
13	75	.....	
15	80	.....	
18	98	.....	
20	103	.....	
23	113	.....	
26	120	.....	Needle of manometer now rose above the top of the registering drum, and the pressure could no longer be followed. Plate V. Fig. 1, represents the tracing of the arterial pressure of this experiment, + corresponding to beginning of irritation at 10 seconds, ++ to cessation of irritation.

4:20 P. M.—The splanchnics divided.

Time. M. Sec.	Arterial Pressure. (Millimetres.)	Irritation.	Remarks.
0	35	.....	Pressure has been steady for some minutes.
10	35	Began.	Strong Faradic current.
13	43	.....	
15	46	.....	
18	49	.....	
30	54	.....	
36	47	.....	Plate V. Fig. 2, represents the tracing of this experiment, + corresponding to beginning of irritation at 10 seconds, ++ to its cessation at 44 secon
44	43	Ceased.	
49	37	.....	
52	35	.....	
1	35	.....	Asphyxia produced.
1:5	44	.....	
1:8	48	.....	After this the pressure did not rise any more.

Autopsy.—The splanchnics cut below the last ribs, just as they are entering the diaphragm. The medulla completely separated from the pons; only one pneumogastric severed in the neck.

This experiment certainly shows that, *after separation of the medulla from the pons and after section of the splanchnics, the arterial pressure still rises, when asphyxia occurs or a sensitive nerve is irritated:* a comparison of this rise with that which occurs when the splanchnics only are divided will show that it is as great as the latter. It must therefore be allowed that there is no vaso-motor centre above that of the medulla, which is able to impress the arterial pressure even when the splanchnics are divided and the dominating power of the abdominal circulation withdrawn. I have also made a series of experiments upon venous pressure, hoping to be able to determine in this way the effect of injuries of the nerve centres upon the blood supply of muscles. No technical difficulties of much importance were met with, the proneness to blood coagulation being overcome by the use of a *saturated* solution of carbonate of sodium; but it was found that the local conditions of the arteries of a part affect very little the venous pressure, the latter being dominated by the general venous pressure and by the muscular condition of the part under study: thus in a number of experiments, section of the

sciatic nerve in the dog had no demonstrable effect upon the blood pressure of the corresponding femoral vein. This method of investigating the matter under consideration led to no result; this is, however, not of vital importance, for it seems scarcely conceivable, that a vaso-motor centre, whose paralysis was followed by dilatation of all the muscular arterioles and whose influence upon heat production should be as great as is required by the facts of the case, should not impress, in any way, the arterial pressure, even after withdrawal of the influence of the abdominal circulation. It seems to me about as nearly demonstrated as it can be that the centre in the medulla dominates the vessels in every part of the body, and consequently that the rise of the heat production following section of the medulla is not due to an influence exerted upon the circulation, but directly upon the heat making function. The theory that teaches the existence of a nerve centre in the pons or in the brain above it, which by a direct action inhibits the production of animal heat, seems therefore to be most in accord with all the evidence bearing upon the matter, and I am myself disposed to adopt it as at least very probable.

It is a matter of much interest to decide as to the location in man of the centres which control the production of heat. I do not believe that it is right to apply rigidly to man, rules of localizations discovered in the cerebral hemispheres of the lower animals. The differentiation, anatomical and functional, is so much greater in the human than in the canine brain, that diversity of anatomical localization is very probable. In determining the seat of caloric inhibition in man a great difficulty offers itself. No human calorimetrical observations have been made at all, and if we judge from a rise of bodily temperature vaso-motor disturbance may be readily mistaken for an increased heat production. It is possible, however, that close observation of apoplectic and traumatic brain cases, aided by cautious reasoning, may, in the future, enable us to trace out the course of the heat fibres, and rather with the desire of giving an impulse to the observation of cases than with the expectation of deciding the question, a brief discussion of the present evidence is here entered upon.

Evidently the first point to direct attention to is in regard to the pons Varolii and the optic thalamus.

Bastian states that in apoplexy of the pons, if the life of the patient be prolonged, "the temperature of both sides of the body steadily rises, till at the time of death it may have attained 109° or even 110°." (*Paralysis from Brain Disease*, p. 220.) He also asserts that after hemorrhage into the optic thalamus the paralyzed limb may be for many weeks or months "one and a half or even two degrees" hotter than the sound limb. Limbs paralyzed by hemorrhage in the corpus striatum, or its neighborhood, are said also to be slightly but temporarily hotter than the sound limb. Upon what or how many cases Dr. Bastian rests these generalizations I do not know. Hemorrhage confined to the optic thalamus is rare. The only case I have a reference to is that reported by Dr. Remy (*Bull. Soc. de Anat.*, Paris, 1875, 3 ser. x. p. 158). In this the original attack came on early in October, 1874, but the subject did not come under observation until the ninth of November. The temperatures as taken in this case were—

Nov. 9. Right hand 32°.9 C., left 36°; right elbow 34°.9, left 35°.3; right axilla 37°.1, left 37°.3.

Dec. 1. Right axilla 37°.0 C., left 37°.2; right elbow 35°.6, left 35°.8.

Hemorrhage limited to the pons is comparatively very frequent, and I have looked up a number of references, with the results shown in the tabulated statements.

Cases with Fever Developed.

Nunneley.	Trans. Lond. Path. Soc., xi. p. 11.	Head at first alone hot; later whole surface.
Alexander.	Lancet, 1875, i. p. 722.	Cross paralysis. Fever only slight, not developed for some hours, then temperature for a while 101°.4 F. in right, 102°.2 in left axilla. Clot occupying the right lower half of the pons not extending beyond the median line.
Johnson.	British Med. Journ., 1877, i. p. 13.	Temperature 1° higher in popliteal space of paralyzed side, lower on sound side; not stated how long this lasted. Cross paralysis. No autopsy.
Lepine.	L'Union Med., 1876, i. p. 961.	Rise of temperature slight and developed slowly; only partial left hemiplegia with muscular contraction. Head rotated towards paralyzed side. Very small clot in right side, about equal distance from front and rear of pons, a little to right of median line.
Rendu.	Bull. Soc. Anat., 1875, p. 75.	Cross paralysis; slight rise of temperature slowly developed; slight immediate rise of temperature in paralyzed side; no sugar or albumen in urine; a large clot in median extending into left cerebral peduncle which it almost entirely occupies; also into fourth ventricle, but only affects summit of ventricle; maximum lesion on left side of ventricle, almost the whole upper third of which is destroyed.
Huchard.	Bull. Soc. Anat., 1868, p. 143.	One hour after attack temperature of right side 36° C., left side 35°.6; right side paralyzed in 1½ hours after the attack. Large clot in left side of pons.

Cases in which Temperature was Normal or Below Normal.

Weber.	Tr. Med. Chirurg. Soc., xliv. p. 153.	Tumor. In section of pons on level with origin of fifth nerve, in lower or anterior part of left half close to periphery, a round tumor half an inch in diameter; softening extended to floor of fourth ventricle and to the right.
Weber.	Ibid.	Tumor, almost identical with last.
Weber.	Ibid.	Softening of pons in centre of superior part nearest cornu cerebri.
Tolédano.	Bull. Soc. Anat., 1875, p. 670.	Temperature 39° C. Considerable hemorrhage into centre of pons, which was softened and disorganized. Fatty degeneration of kidneys.
Pinard.	Bull. Soc. Anat., 1874, p. 37.	Temperature 36°.5 C. Pupils widely dilated. Very large clot occupying anterior part of pons, and breaking into third ventricle; death in three hours.
Browne.	Journ. Mental Science, xxi. (1875–6) p. 256.	

Cases in which there is no Mention of Temperature.

Bristowe.	Trans. Lond. Path. Soc., xi. p. 11.
Ogle.	Trans. Lond. Path. Soc., xi. p. 11.
Ogle.	Trans. Lond. Path. Soc., i. p. 15.
Broadbent.	Trans. Lond. Path. Soc., xii. p. 16.
Morrison.	Trans. Lond. Path. Soc., i. p. 36.
Peacock.	Trans. Lond. Path. Soc., i. p. 36.
Barlow.	Trans. Lond. Path. Soc., iv. p. 28.
Browne.	London Lancet, 1875, i. p. 196.
Spanton.	London Lancet, 1875, i. p. 609.
Herapath.	London Lancet, 1848, ii. p. 72.

Russell.	British Med. Journal, 1868, ii. p. 611.
Harkass.	British Med. Journal, 1868, i. p. 426.
Weber.	British Med. Journal, 1877, i. p. 13.
Wilks.	Med. Times and Gaz., 1863, i. p. 214.
Brown-Séquard.	Med. Times and Gaz., 1863, i. p. 213.
Brown-Séquard.	Med. Times and Gaz., 1862, i. p. 429.
Henrich.	Bull. Soc. Anat., 1874, p. 35.
Senac.	Bull. Soc. Anat., 1850, p. 208.
Desnos.	L' Union Méd., 1873, xv. p. 435.
Paris.	Journal de la Physiologie, 1860, p. 717.
Fenwick.	Canada Med. and Surg. Journal, 1876, iv. p. 121.
Lemaire.	Bull. Soc. Anat., 1863, xxxviii. p. 281.

It is probable in the majority of cases in which no mention is made of the temperature, no marked deviation from normal existed. The only conclusion which it seems to me can be drawn is that further and closer observation is needed before we can come to any positive conclusion as to the location of the heat-controlling centre in man, but that its probable situation is in the pons.

CHAPTER III.

THE THERMIC PHENOMENA OF FEVER.

In the present chapter the chief object of research is the determination of whether the rise of temperature in fever is due to an increased production of heat, or whether it is owing simply to retention of heat? Of course, the problem is a very old one, although not as yet settled. In the various attempts to work it out various methods have been used. These methods may all be classed as either deductive or directly experimental. The deductive attempts have consisted in calculating from the amount of food and tissue-waste in health and fever, the amount of heat which is generated. It is plain that this is more demonstrative than *a priori* reasoning, but it is not as convincing as direct experimentation. Later on, the subject may be considered from this point of view, but at present I shall examine solely the experimental evidence at hand.

The evidence hitherto brought forward consists of experiments made upon man and upon animals. The two most important studies upon man are those of Prof. Liebermeister (*Beobachtungen und Versuche über die anwendung des Kalten Wassers bei Fieberhaften Krankheiten*, Leipzig, 1868) and of E. Leyden (*Deutsches Archiv*, Bd. III.).

Liebermeister's plan consisted in comparing the effects produced by normal and feverish individuals in raising the temperature of cold baths of known quantity and temperature. Several difficulties are in the way of this method; some of these Prof. Liebermeister perceived and overcame more or less completely. It was found that the body cools down very unequally in the bath, the limbs falling much more rapidly than the trunk. This source of error was, to some extent, done away with by beginning the data for the subsequent calculation, after the patient had already been some time in the bath; *i. e.*, after the extremities had already been, in great part cooled. Prof. Liebermeister considers the specific heat of the body at 0.83, which is perhaps a little high; but, in relative experiments, error from such source must in great part disappear. Allowance in all of the experiments was made for the spontaneous cooling of the bath in a way which appears perfectly fair; the basis of this allowance was obtained by permitting, after the removal of the body, the bath to cool for a period of time equal to that during which the body had been in it.

Liebermeister made fourteen experiments upon fever cases, and compared the results with those obtained by König upon healthy men. The conclusion arrived at is,—that when baths of the same temperature are employed, "without exception, the loss of heat in the fever patient is greater than in the well person."

This evidence is very important, but there is one underlying possible fallacy which prevents it from being considered conclusive. According to Liebermeister himself, heat production, both in health and disease, is profoundly affected by the heat

loss. In this way, both in the fevered and in the healthy individual, the cold bath greatly stimulates heat production.

Now it is plainly to be expected that the degree of this stimulation will be in direct proportion to the difference between the temperature of the animal or man and the external cold. The bath of uniform temperature, such as was used by Liebermeister, is not uniform in its relations to the fevered and non-fevered man. Take for example, a bath of 90°; to the normal individual it is a tepid bath only 8°.5 lower than his own temperature, to the patient with a temperature of 106° it is a cool bath 16° below his own temperature. Important, then, as the research of Liebermeister is, the most that can be fairly claimed for it is that it indicates increased heat production as present in fever.

Leyden's experiments were upon a very different plan. He encased a limb of a patient in a calorimeter, similar in its general idea to that employed in the present research by myself, but of course entirely different in the plan of its construction (*Deutsche Archiv*, Bd. III. p. 282). The details of these experiments, and of the form and construction of the calorimeter, may be found in the paper quoted (or in English, in Dr. Burdon Sanderson's article "On the Process of Fever," *Reports of the Medical Officer of the Privy Council*, No. VI., 1875). I shall not recite them.

Prof. Leyden, in his first series of experiments with the legs naked (*op. cit.*, p. 288), found in three healthy men the average heat dissipation of the limb per hour was 0.165 French units; in four fever observations (three cases) it was 0.319. Moreover, in two of the fever patients, comparative studies were made: thus, in No. 4, when the bodily temperature was 40°.2 C. the hourly heat discharge was 0.33; when the bodily temperature was 39°.8 C., the hourly heat discharge was 0.245; in No. 6, when the bodily temperature was 39°.8 C., the hourly heat discharge was 30; when the bodily temperature was 36°.7 C., the hourly heat discharge was 0.14. A series of observations was made upon a case of relapsing fever. The more important of these observations are tabulated in the following table; in the preparation of which I have used the tabulated résumé prepared by Burdon Sanderson:—

CASE I.—RELAPSING FEVER.

No.	Date.	Temp. of Ward. (Cent.)	Temp. of Patient. (Cent.)	Pulse.	Increment of Temperature in Calorimeter. (Cent.)	REMARKS.
1	Oct. 22	18°.6	40°.2	108	0°.21	Extremities undressed. Weight 150 pounds.
2	Oct. 23	18.1	37.1	76	0.18	Moderate amount of sweat under hose.
3	Oct. 24	18.3	37.3	76	0.20	Distinct sweat under hose.
4	Oct. 25	17.75	37.2	72	0.14	Damp under hose.
5	Oct. 26	18.4	37.1	60	0.1	
6	Nov. 2 morning	19.35	39	88	0.155	
7	Nov. 2 afternoon	19.5	40.2	96	0.201	
8	Nov. 3	18.5	39.2	88	0.14	
9	Nov. 4	18.75	37.9	92	0.21	Much sweat, bodily temperature during operation fell to 37° C.
10	Nov. 5 11:30–12:30	18.25	39.9	104	0.11	A decided chill during this observation.
11	Nov. 5 1–1:30	18.25	39.8	...	0.12	
12	Nov. 6	18	37.2	76	0.14	
13	Nov. 7	18.1	36.7	60	0.1	

Case II.—Relapsing Fever.

No.	Date.	Temp. of Ward. (Cent.)	Temp. of Patient. (Cent.)	Pulse.	Increment of Temperature in Calorimeter. (Cent.)	Remarks.
1	Nov. 14	20°.5 (mean)	39°.8	108	0°.16	Male, æt. 18, weight 101 pounds. The numbers bracketed relate to a period of observation of 5 hours, during which the bodily temperature was gradually sinking. The patient was sweating the whole time; most profusely during the middle hour, when the surface loss was greatest.
			38.7	88	0.19	
			.....	...	0.24	
			37.2	64	0.16	
			37	...	0.15	
2	Nov. 15	20.5	36.8	64	0.075	Observations 2 to 6 were made on different days during the *non-febrile* intervals. Each observation lasted 2 hours, of which the mean result is given in each case.
3	Nov. 16	20.3	36.5	68	0.20	
4	Nov. 17	20.5	36.5	64	0.06	
5	Nov. 18	20	36.5	68	0.1	
6	Nov. 19	20	36.5	68	0.1	
7	Nov. 20	19.6	40.6	106	0.145	Observations 7 and 8 were made at 11 A. M. and 6 P. M. of the first day of the relapse. Excessive thirst, very dry skin.
8	Nov. 21	19.4	40.4	108	0.145	
9	Nov. 22	19.4	39	110	0.142	Observation 9 was continued for four hours, viz., from noon to 4 P. M. During the whole time the skin was hot and dry.
10	Nov. 23	.....	40.5	...	0.1	Observation 10 lasted 2 hours, skin being hot and dry.
11	Nov. 23	.....	.....	...	...	Observation lasted 5:45 to 7:45 P. M. Sweating came on during it, and continued all the evening.
12	Nov. 23	.....	.....	...	...	Taken at 8:15 P. M.

Case III.—Relapsing Fever.

No.	Date.	Temp. of Ward. (Cent.)	Temp. of Patient. (Cent.)	Pulse.	Increment of Temperature in Calorimeter. (Cent.)	Remarks.
1	Oct. 29	18°.8	40°	120	0°.19	Male, weight 96 pounds.
2	Oct. 29	18.1	40.5	124	0.14	Observations 2 and 3 followed at intervals of half an hour, during which a rigor occurred.
3	Oct. 29	18.1	.....	...	0.18	
4	Oct. 30	18.5	40.3	124	0.15	
5	Oct. 31	19.7	41.4	120	0.13	Observations 5 and 6 were made during the relapse at 12:5 and 1:45 P. M. of the same day. Before observation 5, patient had had a rigor, and the skin was hot and dry. At 1:15 P. M. sweating came on and continued during the period of observation.
6	Oct. 31	19.8	39.5	...	0.2	
7	Oct. 31	19.9	36.1	80	0.06	Observation 7 was made at 5:35 P. M. the same day.
8	Nov. 8	17.5	37.3	80	0.105	Observation 8 at mid-day, when convalescence was established.

Case IV.—Pneumonia.

No.	Date.	Temp. of Ward. (Cent.)	Temp. of Patient. (Cent.)	Pulse.	Increment of Temperature in Calorimeter. (Cent.)	Remarks.
1	Jan. 8	18°.8	40°	100	0°.192	Male, æt. 19, weight 101 pounds. Observation 1 made at mid-day; skin moist.
2	Jan. 8	18.8	39.2–37.2	92–76	0.26	Observation 2 made at 6:30 P. M., general perspiration.
3	Jan. 11	18.6	37.1	...	0.105	Convalescence.

CASE V.—PNEUMONIA.

No.	DATE.	TEMP. OF WARD. (Cent.)	TEMP. OF PATIENT. (Cent.)	PULSE.	INCREMENT OF TEMPERATURE IN CALORIMETER. (Cent.)	REMARKS.
1	Jan. 11	19°.5	39°.7–40°.5	100	0°.14	Male, æt. 30, weight 130 pounds.
2	Jan. 12	19.9	40.3	100	0.175	
3	Jan. 13	19.5	39.3–38.4	100	0.225	
	Jan. 14	19.5	40.2	108	0.23	
	Jan. 20	17	normal	normal	0.11	

The conclusions drawn by Leyden from his experiments are: The dissipation of heat is increased in fever, both when the bodily temperature is constant, when it is increasing, and when it is diminishing; consequently there is without doubt increased heat production in fever. In the highest fever the rate of giving off of heat is almost double the normal standard. Heat dissipation reaches its maximum in critical periods when the temperature is rapidly falling; under these circumstances it may be three times as rapid as normal. This rapid critical dissipation occurs with profuse sweating, whilst in fever with rising temperature there is no perceptible production of water even under an impermeable cloth. (Während bei ansteigendem Fieber überhaupt keine Wasser Production selbst unter einer imperspirabeln Decke nachweisbar ist.) In epicritical states the heat dissipation sinks below normal.

Prof. Sanderson objects to these conclusions of Leyden. I quote from him *in extenso* (p. 56).

"The careful study of Professor Leyden's results has led me to an interpretation which differs materially from that which he has embodied in his main conclusion. He admits, throughout, the great importance of visible perspiration, *i. e.*, of the secretion of watery fluid by the sweat glands as a condition favoring the discharge of heat from the skin. He points out that in all those of his experiments in which the heating of the calorimetrical water was most rapid, the result could be connected with rapid cooling of the accessible parts of the body, and with profuse sweating. But he finds there were cases in which, notwithstanding the dryness of the skin, the fevered body parted with its heat to the calorimeter with a rapidity which could not possibly be accounted for as the mere result of the greater heat of the surface. In looking through the cases I am unable to find a single instance in which, the state of the skin being noted, it was found that, in the absence of perspiration, the loss from the surface was considerably in excess. This being so I am compelled to associate increased discharge from the surface not with pyrexia, but with sweating, for while on the one hand I find instances in which the patient was in high fever, with only an average of heat loss, I find in the same patient on another day a very active discharge of heat from the surface, but no fever.

"In so far as can be shown that the increased rate at which the fever patient's heat was communicated from the limb to the calorimeter in which it was inclosed is dependent on sweating, the result is of little value or significance as an index of increased production of heat in the living tissues. Under the condition of the experiment, *i. e.*, when a limb is inclosed in an air-tight chamber, the air which occupies the space between the cutaneous surface and that of the chamber soon becomes saturated with moisture. As soon as this state of things is established there is no further loss of heat by the conversion of sweat into vapor; the effect of sweating therefore resolves itself into the more abstraction of the limb to a certain quantity of watery liquid of which the whole of the heat goes into the calorimeter. So far as the body of the patient is concerned, the process is attended with the loss of a certain quantity of water, and manifests itself in a corresponding loss of weight, but so far as relates to the chemical processes by which heat is produced, it fails to afford any information. If for every gramme of water sweated out at the surface, it were the law of the animal economy that an equal quantity of cold water should be ingested, then it might be said with truth

that for every gramme discharged a quantity must be generated in the body sufficient to warm a gramme of water from the ordinary temperature to that of the blood. So far from this being the case, the loss of water is, as a rule, supplied in the diet of fever by liquid, of which the temperature is as high as, or higher than, that which it has to acquire in order to be discharged, in which case it is obvious that the water, as it actually leaves the body cooler than it entered it, must (in so far as it has any appreciable action on the temperature of the body) tend rather to favor the accumulation of heat than to promote its discharge."

I have given this long extract because I am not able to fully see the force of the objection urged by Dr. Sanderson, and do not wish to misrepresent him. The question is simply whether more heat is or is not given off during fever. It makes no difference how the heat is taken out of the body. If it goes from the body in any way at all, it is dissipated—which is the sum of the whole matter. Further, it is well known that cold and not hot drinks are generally used in fever. The amount of heat carried into the system even by hot drinks is proportionally trifling, and I conceive that Dr. Sanderson's idea of the amount of heat carried out by water which escapes vaporization is an exaggeration. Moreover Dr. Leyden very positively asserts that there was increased dissipation in fever cases when there was no transpiration and when there was ascending temperature.

A more plausible objection to Dr. Leyden's method is that it is perfectly conceivable that in fever such alterations of circulation may occur as to change the relation between the limbs and the trunk in regard to the dissipation of heat.

It might also be urged that the experiments were all in the daytime, and that it may be the dissipation of heat is diminished at night. It is difficult to determine how much of force there is in these objections. It does certainly seem a fair conclusion that the investigations of Liebermeister and Leyden, whilst not actually demonstrative, in their accordance corroborate very strongly the theory which teaches that in fever the rate of heat production is beyond its norm.

Prof. Senator has made a very elaborate study in regard to febrile thermogenesis in dogs (*Untersuchungen über die Fieberhaften Process und seine Behandlung*, Berlin, 1873). His experiments were made with a calorimeter similar in its general idea to that employed by myself. The dog to be used was, previous to the experiment, kept fed regularly once a day with a determinate amount of food. From eighteen to twenty-six hours after the last meal he was placed in the calorimeter for a period of from one to four hours. Upon this observation was based the calculation of heat dissipation for the "first hunger day." Twenty-four hours later, no food having been given, an observation was taken for the "second hunger day." After fever had been produced by septic injections, a parallel series of observations was performed, sometimes for two, sometimes for three days. The results of these experiments are summed up in the following table, which I have modified from the article of Prof. Sanderson. It will be noticed that in this table, under the head of "first day," are comprised the "first hunger day" (normal), and the "first fever day" (fever); under that of second day, the "second hunger day" (normal), and the "second fever day" (fever).

OBSERVATION 1.—Weight of animal 11 pounds 10 oz.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	Normal.	39°.0	13.32	12:58 P. M.—	1:58 P. M
	Fever.	39.3	12.46	12:55	1:55
2d day	Normal.	39.0	11.50	12:25	1:25
	Fever.	40.3	11.58	12:43	1:43

OBSERVATION 2.—Weight 16 pounds 4 oz.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	Normal.	39°.1	15.67	12:7 P. M.—	1:7 P. M.
	Fever.	39.4	15.29	12:29	1:29
2d day	Normal.	39.1	17.32	12:23	1:23
	Fever.	40.3	15.57	12:39	1:39

OBSERVATION 3.—Weight 16 pounds.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	Normal.	39°.0	12.64	12:26 P. M.—	1:26 P. M.
	Fever.	39.6	9.91	1:5	2:5
2d day	Normal.	38.8	11.87	12:36	1:36
	Fever.	40.7	14.52	12:25	1:25
3d day	Fever.	40.7	11.87	12:30	1:30

OBSERVATION 4.—Weight 10 pounds 10 oz.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	Normal.	39°.3	8.67	12:37 P. M.—	1:37 P. M.
	Fever.	39.5	9.52	12:57	1:51
2d day	Normal.	39.3	10.24	12:24	1:24
	Fever.	40.7	11.86	12:34	1:34
3d day	Fever.	39.6	9.43	12:37	1:37

OBSERVATION 5.—Weight 9 pounds 9 oz.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	Normal.	38°.9	12.31	10:2 A. M.—	
	Fever.	39.7–40.3	11.97	10:25	2:25 P. M.
2d day	Normal.	38.9	12.67	9:40	1:40
	Fever.	41.0	15.22	10:6	2:6

OBSERVATION 6.—Weight 24 pounds.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	Normal.	39°.0	24.18	11:31 A. M.—	1:31 P.M.
	Fever.	39.2	25.40	10:55	1:55
2d day	Normal.	39.0	24.48	11:31	2:31
	Fever.	40.0	23.59	11:39	2:39

OBSERVATION 7.—Weight 12 pounds 9 oz.

		RECT. TEMP.		HEAT PRODUCTION.		TIME OF OBSERVATION.			
		Morn. (Cent.)	Aftern. (Cent.)	Morn. (Fr. U.)	Aftern. (Fr. U.)	Morning.		Evening.	
1st day	Normal.	38°.8	38°.8	15.94	16.20	10:2 A. M.—	1:2 P. M.—	5:16 P. M. —	6:16 P. M.
	Fever.	38.7	40 7	15.34	17.44	10:11	1:11	4:50	5:50
2d day	Normal.	38.8	38.6	16.47	17.06	10:15	1:15	5:20	6:20
	Fever.	40.0	40.0	15.48	19.50	10:27	1:27	4:42	5:52
3d day	Fever.	40.4	39.9	17.41	15.57	11:54	1:54	4:31	5:31

The conclusions which Senator draws from his own experiments, and the investigations of Liebermeister and Leyden are: that the dissipation of heat is during the chill of early fever lessened, not increased; but that it is increased during the height of the fever, sometimes as much as 70–75 per cent., and still more at the critical febrile decline.

I think a close study of the table, just given, will hardly bear out this conclusion as being fairly derivable from it. I shall not, however, discuss this in detail, because the method of experimentation of Senator seems to me open to such fallacies as to rob it of much of its authoritativeness. The rhythm of animal thermometry, especially in septic disease, indicates a corresponding rhythm in heat production. Now, it is most probable, that in septic fever this rhythm is very different from what it is in the normal state. Hence, comparisons of the fever and normal heat product, made over an hour or so in the twenty-four hours, must yield doubtful results. The comparison should be made for the whole day. For this and other reasons, which it is not necessary to discuss in detail, it has seemed to me that the experiments of Senator are an insufficient basis for answering the question as to heat production in fever.

For the purpose, if possible, of finally solving this first problem in the nature of fever, the following experiments were undertaken:—

Experiment 110.

A male adult cur. Weight 17.5 pounds.

August 2.

1:15 P. M.—Ate one pound of raw liver, lungs, and heart of sheep.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
2:35 P. M.	76°.64	79°.88	77°.24	1088.793	21.5867	3.2613	78.4195	134.101
2:50	76.54	80.33						
3:5	76.44	80.33						
3:20	76.34	81.05						
3:35	76.34	80.72						
3:50	76.28	81.32						
4:5	76.15	82.64						
4:20	76.28	82.76						
4:35	76.15	82.16						
4:50	76.15	81.86						
5:15	76.05	82.4						
5:30	76.05	82.9						
5:45	76.05	82.83						
6	75.92	82.64						
6:15	75.83	82.98						
6:30	75.83	83.05						
6:45	75.83	83.4						
7	75.73	83.64						
7:15	75.73	83.48						
7:30	75.32	82.98	82.4	1413.085	21.867	3.509	78 5825	134.2315
	76.08	82.16	5.16	324.292	0.2803	0.2477	0.163	0.1305
	(mean)	76.08	(gain)	0.2803			(gain)	(gain)
		6.08 (gain)		324.5723				

7:35 P. M.—Rectal temperature 39° C. (102°.2 F.).

August 2 and 3.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
8:57 P. M.	77°.9	81°.9	80°	517.311	21.869	3.505	78.5825	134.2315
9:12	77.36	82.16						
9:27	77.54	82.04						
9:42	77.36	82.16						
9:57	77.9	82.04						
10:12	77.36	81.68						
10:27	77.18	82.62						
10:42	76.64	82.16						
10:57	77.36	81.86						
11:12	77.45	82.62						
11:27	77.45	82.62						
11:42	77.54	83.12						
11:57	77.42	82.98						
12:12 A. M.	77.45	83.96						
12:27	77.45	83.57						
12:42	77.45	83.05						
12:57	77	83.24						
1:12	77.09	83.24						
1:27	77.36	82.98						
1:42	77.45	83.05						
1:57	77.36	82.98	82.4	1041.725	22.188	3.7005	78.731	134.3448
	77.38 (mean)	82.67 77.38	2.4 (gain)	524.414 0.319	0.319	0.1955	0.1485 (gain)	0.1133 (gain)
		5.29 (gain)		524.733				

August 3.

1:57 A. M.—Rectal temperature 39°.13 C. (102°.43 F.).

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
3:30 A. M.	77°.45	81°.05	80°.6	81.828	22.1883	103.7033	78.731	134.3448
3:45	77.27	81.05						
4	77.09	80.72						
4:15	75.55	80.72						
4:30	76.04	80.51						
4:45	75.92	80.24						
5	75.11	80.12						
5:15	75.29	80						
5:30	75.47	84.42						
5:45	75.29	80.33						
6	75.83	81.05						
6:15	76.37	80.72						
6:30	76.55	80.72						
6:45	76.55	81.68						
7	76.64	81.59						
7:15	75.97	81.01						
7:30	76.04	81.05						
7:45	76.28	82.16						
8	76.28	82.76						
8:15	76.28	82.98						
8:30	76.04	83.05	82.04	410.085	22.3395	103.8605	78.7948	134.4352
	76.15 (mean)	81.33 76.15	1.44 (gain)	328.257 0.1512	0.1512	0.1572	0.0638 (gain)	0.0904 (gain)
		5.18 (gain)		328.4082				

8:30 A. M.—Rectal temperature 39°.38 C. (102°.89 F.).

9:30 A. M.—Dog ate one-quarter of a pound of raw liver. Received no further food, but allowed to stay out of box until evening.

August 3.

6:16 P. M.—Barometer 29.9. Rectal temperature 40°.12 C. (104°.2 F.).

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
6:16 P. M.	82°	82°.64	79°.94	493.185	22.3328	3.8573	150.1602	134.4343
6:31	81.59	82.52						
6:46	81.32	82.04						
7:1	80.69	82.68						
7:16	80.36	81.59						
7:31	80.36	81.59						
7:46	80.36	81.68						
8	80.12	81.68						
8:15	79.43	81.59						
8:30	79.43	82.16						
8:45	78.8	81.95						
9	79.25	81.95						
9:15	77.99	82.04						
9:30	78.32	81.68						
9:45	77.63	81.77						
10	77.18	81.77						
10:15	76.76	81.5						
11:30	76.35	81.41						
11:45	76.37	81.32						
11	76.28	81.77						
11:16	77.45	81.86	81.95	864.335	22.6127	4.0523	150.3315	134.5547
	78.95 (mean)	81.86 78.95	2.01 (gain)	371.15 0.2799	0.2799	0.195	0.1713 (gain)	0.1204 (gain)
		2.91 (gain)		371.4299				

11:16 P. M.—Barometer 29.9. Rectal temperature 39°.5 C. (103°.1 F.).

August 4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
12:10 A. M.	78°.20	81°.59	80°.51	912.46	22.6132	4.0545	150.3315	134.5547
12:25	77.72	81.59						
12:40	77.18	81.41						
12:55	77.81	81.41						
1:10	77.9	81.68						
1:25	78.32	81.68						
1:40	78.08	81.68						
1:55	77.99	81.59						
2:10	77.45	81.41						
2:25	77.45	81.5						
2:55	77.09	81.5						
3:10	76.55	81.41						
3:40	76.2	81.05						
3:55	75.44	81.23						
4:10	75.32	81.04						
4:25	75.2	80.96						
4:40	75.2	81.05						
4:55	74.6	80.72						
5:10	73.94	80	81.59	1291.545	22.7407	4.3382	150.3554	134.6288
	76.72 (mean)	81.29 76.72	1.08 (gain)	379.085 0.1275	0.1275	0.2837	0.0239 (gain)	0.0741 (gain)
		4.57 (gain)		379.2125				

5:10 A. M.—Barometer 29.9. Rectal temperature 39°.5 C. (103°.1 F.).

August 4.

Time.	Air Temp. (Fah.)	Tubb Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
6:23 A. M.	74°.6	79°.43	79°.61	360.045	22.7407	104.3382	150.3554	134.6288
6:38	74.12	79.52						
6:53	73.85	79.16						
7:8	73.1	79.04						
7:23	73.4	79.64						
7:38	73.85	80.51						
7:53	73.64	80.6						
8:8	74.94	80.72						
8:23	74.3	81.23						
8:38	74.3	81.23						
8:53	74.39	81.41						
9:8	74.12	81.41						
9:23	74.03	81.41						
9:38	74.3	81.59						
9:53	74.5	80.96						
10:8	74.39	81.05						
10:23	74.6	82.04						
10:38	74.6	80.84						
10:53	74.72	79.48						
11:8	74.6	78.53						
11:23	74.88	80	81.41	733.035	22.9434	104.5807	150.4543	134.7362
	74.23 (mean)	80.47	1:8 (gain)	372.99	0.2027	0.2425	0.0989 (gain)	0.1074 (gain)
		74.23		0.2027				
		6.24 (gain)		373.1927				

11:23 A. M.—Barometer 29.95. Rectal temperature 39° C. (102°.2 F.)

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
1:30 P. M.	76°.73	78°.53	77°.52	796.22	22.9438	104.5815	150.4543	134.7362
1:45	76.55	78.53						
2	76.55	78.8						
2:15	77.	79.16						
2:30	77.36	79.43						
2:45	77.54	79.43						
3	77.54	79.43						
3:15	77.45	79.64						
3:30	77.90	80.	78.56	944.96	23.1158	104.7018	150.5445	134.7868
	77.18 (mean)	79.22	1.04 (gain)	148.74	0.172	0.1203	0.0902 (gain)	0.0506 (gain)
		77.18		0.172				
		2.04 (gain)		148.912				

3:30 P. M.—Barometer 30. Rectal temperature 39° C. (102°.2 F.).

August 6.

1:37 P. M.—Barometer 30 Rectal temperature 39° C. (102°.2 F.).

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
1:37 P.M.	78°.72	79°.04	77°.9	34.197	23.1051	104.7075	150.5472	134.7868
1:52	78.8	80.33						
2:7	79.24	80.24						
2:22	79.93	80.96						
3:37	79.84	81.05						
2:52	80.68	81:8						
3:7	80.6	82.57						
3:22	81.45	81.68						
3:37	81.84	80.51						
3:52	79.45	81.68						
4:7	80.88	82.52						
4:22	80.88	82.92						
4:37	80.6	82.76						
4:52	80.6	83.24						
5:7	80.6	83.75						
5:22	80.6	83.75						
5:37	80.57	83.65						
5:52	80.51	83.48						
6:7	80.6	83.05						
6:22	80.69	83.2						
6:37	80.69	83.05	81.77	370.427	23.4053	105.063	150.7518	134.948
	80.37 (mean)	82.14 80.37	3.87 (gain)	336.23 0.3002	0.3002	0.3555	0.2046 (gain)	0.1612 (gain)
		1.77 (gain)		336.5302				

6:37 P. M.—Barometer 29.9. Rectal temperature 40° C. (104° F.).

August 6 and 7.

8:9 P. M.—Barometer 29.9. Rectal temperature 40° C. (104° F.).

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
8:9 P. M.	80°.48	81°.79	79°.52	427.65	23.4053	105.0645	150.7518	134.948
8:24	79.88	81.32						
8:39	79.52	80.96						
8:54	79.25	81.68						
9:9	78.92	81.59						
0:24	78.56	82.04						
9:39	78.44	82.77						
9:54	77.99	81.59						
10:9	77.9	81.41						
10:24	77.72	79.88						
10:39	77.54	81.68						
10:54	77.09	81.5						
11:9	76.64	81.77						
11:24	77.27	81.77						
11:39	77.18	81.77						
11:54	76.55	81.68						
12:9 A. M.	76.16	81.59						
12:24	76.16	81.41						
12:39	76.04	81.68						
12:54	75.92	81.59						
1.9	75.92	81.59	81.72	766.782	23.6728	105.3185	150.8641	135.04
	77.67 (mean)	81.57 77.67	2.2 (gain)	339.132 0.2675	0.2675	0.254	0.1123 (gain)	0.092 (gain)
		3.9 (gain)		339.3995				

1:9 A. M.—Barometer 29.9. Rectal temperature 40°.37 C. (104°.67 F.).

August 7.

2:58 P. M.—Barometer 29.9. Rectal temperature 40°.37 C. (104°.67 F.).

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
2:58 P. M.	76°.01	81°.23	80°.55	825.125	23.6728	105.3185	150.8641	135.04
3:13	75.92	80.96						
3:28	75.56	80.84						
3:43	75.2	80.84						
3:58	74.72	81.05						
4:13	74.6	80.84						
4:28	74.21	82.32						
4:43	74.3	80.96						
4:58	73 88	80.84						
5:13	73.88	80.6						
5:28	74.3	80.84						
5:43	74.3	80.96						
5:58	74.6	81.05						
6:13	74.72	81.32						
6:28	74.6	81.23						
6:43	74.6	80.96						
7:13	74.48	81.05						
7:28	75.65	81.14						
7:43	75.44	80.96						
7:58	75.83	81.5	81.71	1241.543	23.8268	105.4373	150.9462	135.0875
	74.89 (mean)	81.07	1.16 (gain)	416.418	0.154	0.1188	0.0821 (gain)	0.0475 (gain)
		74.89		0.154				
		6.18 (gain)		416.572				

7:58 P. M.—Barometer 29.89. Rectal temperature 40° C. (104° F.).

6:27 P. M.—Barometer 29.8. Rectal temperature 41°.125 C. (106°.02 F.).

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
6:27 P. M.	80°.48	81°.54	78°.845	379.913	23.8248	105.434	126.4666	110.394
6:42	80.48	81.14						
6:57	80.24	81.05						
7:12	80.	80.96						
7:27	80.12	81 05						
7:42	79.04	81.77						
7:57	78.92	82.16						
8:12	78.80	82.90						
8:27	78.68	82.91						
8:57	78.44	82.64						
9:12	77.9	82.52						
9:27	77.9	82.98						
9:42	78.08	83.36						
9:57	77.9	83.05						
10:12	77.81	83.12						
10:27	77.72	83.12						
10:42	77.45	83.36						
10:57	77.9	83.24						
11:12	77.98	83.36						
11:27	77.54	83.36	82.88	708.518	24.031	105.5903	126.5968	110.9652
	78.66 (mean)	82.48	4.035 (gain)	328.605	0.2062	0.1563	0.1302 (gain)	0.0742 (gain)
		78.66		0.2062				
		3.82 (gain)		328.8112				

11:27 P. M.—Barometer 29.82. Rectal temperature 41° C. (105°.8 F.).

August 8.

1:4 A. M.—Barometer 28.82. Rectal temperature 41°.625 C. (106°.92 F.).

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
1:4 A. M.	79°.64	82°.28	79°.88	754.086	24.0307	105.5913	126.5968	111.0394
1:19	78.56	81.59						
1:40	77.36	81.68						
1:49	77.09	81.5						
2:4	77.18	81.68						
2:19	77.36	81.68						
2:34	77.63	82.16						
2:49	77.81	82.52						
3:4	77.72	82.16						
3:19	77 36	82.4						
3:34	77.45	82.76						
3:49	77.45	82.4						
4:4	77.36	82.52						
4:19	77.27	82.16						
4:34	76.76	82.04						
4:49	77.18	81.59						
5:4	77.18	81.68						
5:19	76.88	81.86						
5:34	77.	82.28						
5:49	76.37	82.16						
6:4	75.56	82.04	82.16	1059.62	24.1681	105.7322	126.6821	111.17
	77.34 (mean)	82.06 77.34	2.28 (gain)	305.534 0.1374	0.1374	0.1409	0.0853 (gain)	0.1306 (gain)
		4.72 (gain)		305.6714				

6:4 P. M.—Barometer 29.92. Rectal temperature 40° C (104° F.).

7.42 P. M.—Rectal temperature 40°.5 C. (104°.9 F.).

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
7:42 A.M.	77°.99	80°.24	79°.52	1102.809	24.1694	105.7308	126.6821	111.17
7:57	78.2	80.51						
8:12	78.2	80.51						
8:27	78.2	80.6						
8:42	78.56	80.84						
8:57	78.92	80.6						
9:12	79.16	80.96						
9:27	79.25	81.14						
9:42	79.52	81.23						
9:57	79.88	81.05						
10:12	80.36	81.23						
10:27	80.36	81.5						
10:32	80.24	81.5						
10:47	80.6	81.5						
11:2	80.6	81.5						
11:17	80.69	81.5						
11:37	81.41	81.68						
11:52	81.08	81.68						
12:7 P. M.	80.96	81.59						
12:22	81.08	81.68						
12:38	81.2	81.95						
12:42	.....	.....	81.555	1418.082	24.5001	106.0573	126.8885	111.2583
	79.84 (mean)	81.19 79.84	2.035 (gain)	315.273 0.3307	0.3307	0.3265	0.2064 (gain)	0.0883 (gain)
		1.35 (gain)		315.6037				

12:42 P. M.—Rectal temperature 40°.5 C. (104°.9 F.).

Heat Dissipation.

First Period—

Quantity of air (V′) = 324.5723 at 82°.16 — 32° = 50.16 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{324.5723}{1.102} = 294.5$. $W = V \times 0.08073 = 23.8$

Rise in temp. of air 6.08 = t. $Q = W \times t \times$ sp. h. $= 23.8 \times 6.08 \times 0.2374 = 34.3527$ heat given to air.
Quotient for box $1157 \times 0.163 = 188.591$ = moisture leaving box.
Quotient for air $1310 \times 0.1305 = 170.955$ = moisture entering box.

17.636 = moisture vaporized in box.

$\frac{17.636}{6.2789} = 2.8088$ = heat expended in vaporization.

Rise in temp. of water $5.16 \times 164.1414 = 846.9696$ = heat given to calorimeter.
34.3527 = heat given to air.
2.8088 = heat expended in vaporization.

884.1311 = heat dissipated in 5 hours.

Hourly dissipation of heat 176.8262

Second Period—

Quantity of air (V′) = 524.733 at 82°.67 — 32° = 50.67 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{524.733}{1.103} = 475$. $W = V \times 0.08073 = 38.35$

Rise in temp. of air 5.29 = t. $Q = W \times t \times$ sp. h. $= 38.35 \times 5.29 \times 0.2374 = 48.1617$ = heat given to air.
Quotient for box $1645 \times 0.1485 = 244.2825$ = moisture leaving box.
Quotient for air $2684 \times 0.1133 = 304.0972$ = moisture entering box.

59.8147 = moisture condensed in box.

$\frac{59.8147}{6.2789} = 9.5262$ = heat gained from condensation.

Rise in temp. of water $2.4 \times 164.1414 = 393.9394$ = heat given to calorimeter.
48.1617 = heat given to air.

442.1011
9.5262 = heat gained from condensation.

432.5749 = heat dissipated in 5 hours.

Hourly dissipation of heat 86.515

Third Period—

Quantity of air (V′) = 328.4082 at 81°.33 — 32° = 49.33 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{328.4082}{1.1} = 298.5$. $W = V \times 0.08073 = 24.1$

Rise in temp. of air 5.18 = t. $Q = W \times t \times$ sp. h. $= 24.1 \times 5.18 \times 0.2374 = 29.6365$ = heat given to air.
Quotient for box $2172 \times 0.0638 = 138.5736$ = moisture leaving box.
Quotient for air $2089 \times 0.0904 = 188.8456$ = moisture entering box.

50.272 = moisture condensed in box.

$\frac{50.272}{6.2789} = 8.0065$ = heat gained from condensation.

Rise in temp. of water $1.44 \times 164.1414 = 236.3636$ = heat given to calorimeter.
29.6365 = heat given to air.

266.0001
8.0064 = heat gained from condensation.

257.9937 = heat dissipated in 5 hours.

Hourly dissipation of heat 51.5987

Fourth Period—

Quantity of air (V′) = 371.4299 at 81°.86 — 32° = 49.86 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{371.4299}{1.1} = 337.6$. $W = V \times 0.08073 = 27.2$

Rise in temp. of air 2.91 = t. $Q = W \times t \times$ sp. h. $= 27.2 \times 2.91 \times 0.2374 = 18.7902$ = heat given to air.
Quotient for box 1327 $\times$ 0.1713 = 227.3151 = moisture leaving box.
Quotient for air 1904.6 $\times$ 0.1204 = 229.3138 = moisture entering box.

1.9987 = moisture condensed in box.

$\frac{1.9987}{6.2789} = 0.3181$ = heat gained from condensation.
Rise in temp. of water 2.01 $\times$ 164.1414 = 329.9242 = heat given to calorimeter.

18.7902 = heat given to air.

348.7144
0.3181 = heat gained from condensation.

348.3963 = heat dissipated in 5 hours.
Hourly dissipation of heat 69.6793

Fifth Period—

Quantity of air (V′) = 379.2125 at 81°.29 — 32° = 49.29 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{379.2125}{1.1} = 344.5$. $W = V \times 0.08073 = 27.8$

Rise in temp. of air 4.57 = t. $Q = W \times t \times$ sp. h. $= 27.8 \times 4.57 \times 0.2374 = 30.1607$ = heat given to air.
Quotient for box 2976.3 $\times$ 0.0239 = 71.1336 = moisture leaving box.
Quotient for air 1337.6 $\times$ 0.0741 = 99.1458 = moisture entering box.

28.0122 = moisture condensed in box.

$\frac{28.012}{6.2789} = 4.4613$ = heat gained from condensation.
Rise in temp. of water 1.08 $\times$ 164.1414 = 177.2727 = heat given to calorimeter.

30.1607 = heat given to air.

207.4334
4.4613 = heat gained from condensation.

202.9721 = heat dissipated in 5 hours.
Hourly dissipation of heat 40.5944

Sixth Period—

Quantity of air (V′) = 373.1927 at 80°.47 — 32° = 48.47 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{373.1927}{1.099} = 340$. $W = V \times 0.08073 = 27.4$

Rise in temp. of air 6.24 = t. $Q = W \times t \times$ sp. h. $= 27.4 \times 6.24 \times 0.2374 = 40.5897$ = heat given to air.
Quotient for box 1841.1 $\times$ 0.0989 = 182.0848 = moisture leaving box.
Quotient for air 1216.5 $\times$ 0.1074 = 164.278 = moisture entering box.

17.8068 = moisture vaporized in box.

$\frac{17.8068}{6.2789} = 2.836$ = heat expended in vaporization.
Rise in temp. of water 1.8 $\times$ 164.1414 = 295.4545 = heat given to calorimeter.

40.5897 = heat given to air.
2.836 = heat expended in vaporization.

338.8802 = heat dissipated in 5 hours.
Hourly dissipation of heat 67.776

Seventh Period—

Quantity of air (V′) = 148.912 at 79°.22 — 32° = 47.22 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{148.912}{1.0961} = 135.9$. $W = V \times 0.08073 = 10.97$

Rise in temp. of air 2.04 = t. $Q = W \times t \times$ sp. h. $= 10.97 \times 2.04 \times 0.2374 = 5.3173$ = heat given to air.

Quotient for box 865.8 × 0.0902 = 78.0952 = moisture leaving box.
Quotient for air 1237.8 × 0.0506 = 62.6327 = moisture entering box.

15.4625 = moisture vaporized in box.

$\frac{15.4625}{6.2789} = 2.4629$ = heat expended in vaporization.

Rise in temp. of water 1.04 × 164.1414 = 170.7071 = heat given to calorimeter.
5.3173 = heat given to air.
2.4629 = heat expended in vaporization.

178.4873 = heat dissipated in 2 hours.

Hourly dissipation of heat 89.2437

Eighth Period—

Quantity of air (V′) = 336.5302 at 82°.14 — 32° = 50.14 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{336.5302}{1.102} = 305.4$. $W = V \times 0.08073 = 24.6$

Rise in temp. of air 1.77 = t. $Q = W \times t \times$ sp. h. = 24.6 × 1.77 × 0.2374 = 10.3369 = heat given to air.
Quotient for box 1121. × 0.2046 = 229.3566 = moisture leaving box.
Quotient for air 949.8 × 0.1612 = 153.5919 = moisture entering box.

76.7647 = moisture vaporized in box.

$\frac{76.7647}{6.2789} = 12.2258$ = heat expended in vaporization.

Rise in temp. of water 3.87 × 164.1414 = 635.2272 = heat given to water.
10.3369 = heat given to air.
12.2258 = heat expended in vaporization.

657.7899 = dissipation of heat in 5 hours.

Hourly dissipation of heat 131.558

Ninth Period—

Quantity of air (V′) = 339.3995 at 81°.57 — 32° = 49.57 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{339.3995}{1.1} = 308.5$. $W = V \times 0.08073 = 24.9$

Rise in temp. of air 3.9 = t. $Q = W \times t \times$ sp. h. = 24.9 × 3.9 × 0.2374 = 23.0539 = heat given to air.
Quotient for box 1231.4 × 0.1123 = 138.2862 = moisture leaving box.
Quotient for air 1336.2 × 0.092 = 122.9302 = moisture entering box.

15.356 = moisture vaporized in box.

$\frac{15.356}{6.2789} = 2.4615$ = heat expended in vaporization.

Rise in temp. of water 2.2 × 164.1414 = 361.1111 = heat given to water.
23.0539 = heat given to air.
2.4615 = heat expended in vaporization.

386.6265 = dissipation of heat in 5 hours.

Hourly dissipation of heat 77.3253

Tenth Period—

Quantity of air (V′) = 416.572 at 81°.07 — 32° = 49.07 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{416.572}{1.1} = 378.7$. $W = V \times 0.08073 = 30.6$

Rise in temp. of air 6.18 = t. $Q = W \times t \times$ sp. h. = 30.6 × 6.18 × 0.2374 = 44.8942 = heat given to air.
Quotient for box 2705 × 0.0821 = 222.0805 = moisture leaving box.
Quotient for air 3506.5 × 0.0475 = 166.5588 = moisture entering box.

55.5217 = moisture vaporized in box.

$\frac{55.5217}{6.2789} = 8.8426$ = heat expended in vaporization.

Rise in temp. of water $1.16 \times 164.1414 = 190.404$ = heat given to water.
44.8942 = heat given to air.
8.8426 = heat expended in vaporization.
244.1408 = dissipation of heat in 5 hours.
Hourly dissipation of heat 48.881

Eleventh Period—

Quantity of air (V′) = 328.8112 at $82.48° - 32° = 50.48 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{328.8112}{1.103} = 298.1$. $W = V \times 0.08073 = 24.07$

Rise in temp. of air 3.82 = t. $Q = W \times t \times$ sp. h. $= 24.07 \times 3.82 \times 0.2374 = 21.8283$ = heat given to air.
Quotient for box $1594.6 \times 0.1302 = 207.6169$ = moisture leaving box.
Quotient for air $2103.1 \times 0.0742 = 156.05$ = moisture entering box.
51.5669 = moisture vaporized in box.
$\frac{51.5669}{6.2789} = 8.2127$ = heat expended in vaporization.
Rise in temp. of water $4.035 \times 164.1414 = 662.3105$ = heat given to water.
21.8283 = heat given to air.
8.2127 = heat expended in vaporization.
692.3515 = dissipation of heat in 5 hours.
Hourly dissipation of heat 138.4703

Twelfth Period—

Quantity of air (V′) = 305.6714 at $82°.06 - 32° = 50.06 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{305.6714}{1.102} = 277.4$. $W = V \times 0.08073 = 22.3$

Rise in temp. of air 4.72 = t. $Q = W \times t \times$ sp. h. $= 22.3 \times 4.72 \times 0.2374 = 24.9878$ = heat given to air.
Quotient for box $2224.7 \times 0.0853 = 189.7669$ = moisture leaving box.
Quotient for air $2169.4 \times 0.1306 = 283.3236$ = moisture entering box.
93.5567 = moisture condensed in box.
$\frac{93.5567}{6.2789} = 14.9$ = heat gained from condensation.
Rise in temp. of water $2.28 \times 164.1414 = 374.2424$ = heat given to water.
24.9878 = heat given to air.
399.2302
14.9 = heat gained from condensation.
384.3302 = dissipation of heat in 5 hours.
Hourly dissipation of heat 76.866

Thirteenth Period—

Quantity of air (V′) = 315.6037 at $81°.19 - 32° = 49.19 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{315.6037}{1.1} = 287$. $W = V \times 0.08073 = 23.3$

Rise in temp. of air 1.35 = t. $Q = W \times t \times$ sp. h. $= 23.3 \times 1.35 \times 0.2374 = 7.4674$ = heat given to air.
Quotient for box $954.3 \times 0.2064 = 196.9675$ = moisture leaving box.
Quotient for air $966.6 \times 0.0883 = 35.3508$ = moisture entering box.
111.6167 = moisture vaporized in box.
$\frac{111.6167}{6.2789} = 17.7769$ = heat expended in vaporization.
Rise in temp. of water $2.035 \times 164.1414 = 334.0278$ = heat given to water.
7.4674 = heat given to air.
17.7769 = heat expended in vaporization.
359.2721 = dissipation of heat in 5 hours.
Hourly dissipation of heat 71.8544

Heat Production.

First Period—

No change of bodily temperature.
Heat dissipated hourly = *hourly production of heat* 176.8262

Second Period—

Rise of bodily temperature in 5 hours 0°.1806, in 1 hour 0.036 = t.
Q = W × t × sp. h. = 17.5 × 0.036 × 0.75 = 0.4725 = heat added to reserve.

86.515	= hourly dissipation of heat.
0.4725	= hourly addition to heat reserve.
Hourly production of heat	86.9875

Third Period—

Rise of bodily temperature in 5 hours 0°.3515, in 1 hour 0.0703 = t.
Q = W × t × sp. h. = 17.5 × 0.0703 × 0.75 = 0.9227 = heat added to reserve.

51.5987	= hourly dissipation of heat.
0.9227	= hourly addition to heat reserve.
Hourly production of heat	52.5214

Fourth Period—

Fall of bodily temperature in 5 hours 1°.1, in 1 hour 0.22 = t.
Q = W × t × sp. h. = 17.5 × 0.22 × 0.75 = 2.8875 = heat taken from reserve.

69.6793	= hourly dissipation of heat.
2.8875	= hourly loss from heat reserve.
Hourly production of heat	66.8918

Fifth Period—

No change of bodily temperature.
Heat dissipated hourly = *hourly production of heat* 40.5944

Sixth Period—

Fall of bodily temperature in 5 hours 0°.724, in 1 hour 0.145 = t.
Q = W × t × sp. h. = 17.5 × 0.145 × 0.75 = 1.9031 = heat taken from reserve.

67.776	= hourly dissipation of heat.
1.9031	= hourly loss from heat reserve.
Hourly production of heat	65.8729

Seventh Period—

No change of bodily temperature.
Heat dissipated hourly = *hourly production of heat* 89.2437

Eighth Period—

Rise of bodily temperature in 5 hours 1°.8, in 1 hour 0.36 = t.
Q = W × t × sp. h. = 17.5 × 0.36 × 0.75 = 4.725 = heat added to reserve.

131.558	= hourly dissipation of heat.
4.725	= hourly addition to reserve.
Hourly production of heat	136.283

Ninth Period—

Rise of bodily temperature in 5 hours 0°.67, in 1 hour 0.134 = t.
Q = W × t × sp. h. = 17.5 × 0.134 × 0.75 = 1.7588 = heat added to reserve.

77.3253	= hourly dissipation of heat.
1.7588	= hourly addition to reserve.
Hourly production of heat	79.0841

23 July, 1880.

Tenth Period—

Fall of bodily temperature in 5 hours 0°.67, in 1 hour 0°.134 = t.
Q = W × t × sp. h. = 17.5 × 0.134 × 0.75 = 1.7588 = heat taken from reserve.

48.8281 = hourly dissipation of heat.
1.7588 = heat taken from reserve.

Hourly production of heat 47.0693

Eleventh Period—

Fall of bodily temperature in 5 hours 0°.4, in 1 hour 0°.08 = t.
Q = W × t × sp. h. = 17.5 × 0.08 × 0.75 = 1.05 = heat taken from reserve.

138.4703 = hourly dissipation of heat.
1.05 = heat taken from reserve.

Hourly production of heat 137.4203

Twelfth Period—

Fall of bodily temperature in 5 hours 2°.92, in 1 hour 0.584 = t.
Q = W × t × sp. h. = 17.5 × 0.584 × 0.75 = 7.665 = heat taken from reserve.

76.866 = hourly dissipation of heat.
7.665 = heat taken from reserve.

Hourly production of heat 69.201

Thirteenth Period—

No change of bodily temperature.
Heat dissipated hourly = *hourly production of heat* 71.8544

RECAPITULATION.

Day.	Time.	Hourly Heat Dissipation.	Hourly Heat Production.	Rect. Temp. (Fah.)	Remarks.
First day. Aug. 2, 2:30 P. M. to Aug. 3, 2:30 P. M.	2:35 P. M. to 7:35 P. M.	176.8262	176.8262	102°.2	Ate just before going in, one pound of raw liver.
	8:57 P. M. to 1:57 A. M.	86.515	86.9875	102.2 to 102°.43	
	3:30 A. M. to 8:30 A. M.	51.5987	52.5214	102.43 to 102.89	
Second day. Aug. 3, 3:30 P. M. to Aug. 4, 3:30 P. M.	6:16 P. M. to 11:16 P. M.	69.6793	66.6627	102.89 to 103.1	Ate at 9:30 A. M. $\frac{1}{4}$ of lb. of raw liver; no further food.
	12:10 A. M. to 5:10 A. M.	40.5944	40.5944	103.1	
	6:23 A. M. to 11:23 A. M.	67.776	65.8729	103.1 to 102.2	
	1:30 A. M. to 3:30 P. M.	89.2437	89.2437	102.2	
Third day. Aug. 6, 1:30 P. M. to Aug. 7, 1:30 P. M.	1:37 P. M. to 6:37 P. M.	131.558	136.283	102.2 to 104	
	8:9 P. M. to 1:9 A. M.	77.3253	79.0841	104 to 104.67	
	2:58 A. M. to 7:58 A. M.	48.8281	47.0693	104.67 to 104	
Fourth day. Aug. 7, 2 P. M. to Aug. 8, 2 P. M.	6:27 P. M. to 11:27 P. M.	138.4703	137.4203	106.02 to 105.8	
	1:4 A. M. to 6:4 A. M.	76.866	69.201	106.92 to 104	
	7:42 A. M. to 12:42 P. M.	71.8544	71.8544	104.9	

SUMMARY.

	Time in Calorimeter.	Average Hourly Heat Dissipation.	Average Hourly Heat Production.	Extremes of Rect. Temp. (Fah.)	Average Rect. Temp.
First day.	15 hours.	104.9799	105.445	102°.2 to 103°.1	102°.39
Second day.	17 hours.	62.8668	61.4198	104.2 to 102.2	102.83
Third day.	15 hours.	85.9028	87.4787	102.2 to 104.67	103.92
Fourth day.	15 hours.	95.7302	92.8252	104 to 106.92	105.42

Experiment 111.

A long-haired cur. Weight 39 pounds; has had no food since April 8, 6 P. M., when he ate one pound of liver.

April 9.

12:33 P. M.—Rectal temperature 102°.85.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks.
1:20 P. M.	70°	69°.85	68°	910.575	27.99	108.5515	65.6517	58.6281	Howling.
1:35	67.37	70.88	.....	.....	.....	.....	.....	.....	Howling.
1:50	68.36	70.43	.....	.....	.....	.....	.....	.....	Howling.
2:5	68.36	69.95	.....	.....	.....	.....	.....	.....	
2:20	68.52	70.64	.....	.....	.....	.....	.....	.....	
2:35	67.28	70.64	.....	.....	.....	.....	.....	.....	
2:50	67.16	70.25	.....	.....	.....	.....	.....	.....	
3:5	65.75	70.25	.....	.....	.....	.....	.....	.....	Quiet.
3:20	66.47	70.43	.....	.....	.....	.....	.....	.....	Quiet.
3:35	65.30	69.85	.....	.....	.....	.....	.....	.....	Whining.
3:50	62.96	69.26	.....	.....	.....	.....	.....	.....	Whining.
4:5	66.47	71.06	.....	.....	.....	.....	.....	.....	Whining, very uneasy.
4:20	68.54	71.6	.....	.....	.....	.....	.....	.....	Whining.
4:35	66.68	70.88	.....	.....	.....	.....	.....	.....	Quiet.
4:50	66.56	70.76	.....	.....	.....	.....	.....	.....	Whining.
5:5	66.38	71.15	.....	.....	.....	.....	.....	.....	Quiet.
5:20	66.2	71.51	.....	.....	.....	.....	.....	.....	Quiet.
5:35	65.48	70.34	.....	.....	.....	.....	.....	.....	Whining, very uneasy.
5:50	65.66	71.51	.....	.....	.....	.....	.....	.....	Whining.
6:5	65.77	71.06	.....	.....	.....	.....	.....	.....	Whining.
6:20	67.04	72.32	71.96	1425.59	28.2286	108.6992	65.74	58.6542	Whining.
	66.77 (mean)	70.695 66.77	3.96 (gain)	515.015 0.2386	0.2386	0.1477	0.0883 (gain)	0.0261 (gain)	
		3.92 (gain)		515.2536					

6:35 P. M.—Rectal temperature 104°.7. 6:40 P. M.—Dog ate one and a half pounds of raw liver.

April 9 and 10.

7:37 P. M.—Rectal temperature 103°.9.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks.
7:37 P. M.	64°.31	68°.24	68°.45	469.176	28.229	8.7995	65.74	58.6542	Whining.
8:7	65.56	70.25	.....	.....	.....	.....	.....	.....	Quiet.
8:22	65.88	69.64	.....	.....	.....	.....	.....	.....	Whining.
8:37	65.56	69.64	.....	.....	.....	.....	.....	.....	Quiet.
8:52	65.48	69.35	.....	.....	.....	.....	.....	.....	Quiet.
9:7	65.39	68.96	.....	.....	.....	.....	.....	.....	Whining.
9:22	65.66	68.72	.....	.....	.....	.....	.....	.....	Quiet.
9:37	65.66	68.96	.....	.....	.....	.....	.....	.....	Quiet.
9:52	65.75	70.06	.....	.....	.....	.....	.....	.....	Whining.
10:7	65.96	69.64	.....	.....	.....	.....	.....	.....	Quiet.
10:22	66 08	69.64	.....	.....	.....	.....	.....	.....	Quiet.
10:37	66.38	69.74	.....	.....	.....	.....	.....	.....	Quiet.
10:52	66.47	69.84	.....	.....	.....	.....	.....	.....	Quiet.
11:7	66.38	69.94	.....	.....	.....	.....	.....	.....	Quiet.
11:22	66.8	69.96	.....	.....	.....	.....	.....	.....	Quiet.
11:37	66.38	70.16	.....	.....	.....	.....	.....	.....	Whining.
11:52	66.68	69.54	.....	.....	.....	.....	.....	.....	Whining.
12:7 A. M.	66.68	70 43	.....	.....	.....	.....	.....	.....	Whining.
12:22	68.81	72.77	.....	.....	.....	.....	.....	.....	Whining.
12:37	69.92	71.06	71.58	938.815	28.4905	8.9585	65.8413	58.6876	Quiet.
	66.29 (mean)	69.83 66.29	3.13 (gain)	469.639 0.2615	0.2615	0.159	0.1013 (gain)	0.0334 (gain)	
		3.54 (gain)		469.9005					

12:37 A. M.—Rectal temperature 104°.4.

April 10.

1:45 A. M.—Rectal temperature 103°.9.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks.
2:20 A. M.	66°.29	69°.64	68°.7	1036.07	28.49165	8.9572	65.8413	58.6876	
2:35	66.08	69.64	.....	.....	.....	.....	.....	.....	Quiet.
2:50	65.39	69.64	.....	.....	.....	.....	.....	.....	Whining.
3:5	67.04	70.61	.....	.....	.....	.....	.....	.....	Whining.
3:20	67.16	70.79	.....	.....	.....	.....	.....	.....	Quiet.
3:35	68.24	70.88	.....	.....	.....	.....	.....	.....	Quiet.
3:50	68.81	70.61	.....	.....	.....	.....	.....	.....	Howling.
4:5	68.9	72.32	.....	.....	.....	.....	.....	.....	Quiet.
4:20	68.99	71.42	.....	.....	.....	.....	.....	.....	Quiet.
4:35	69.52	71.42	.....	.....	.....	.....	.....	.....	Whining.
4:50	69.53	72.08	.....	.....	.....	.....	.....	.....	Quiet.
5:5	69.53	71.72	.....	.....	.....	.....	.....	.....	Quiet.
5:20	68.99	71.33	.....	.....	.....	.....	.....	.....	Quiet.
5:35	69.08	70.43	.....	.....	.....	.....	.....	.....	Quiet.
5:50	69.08	70.52	.....	.....	.....	.....	.....	.....	Quiet.
6:5	69.2	70.76	.....	.....	.....	.....	.....	.....	
6:20	69.08	71.96	.....	.....	.....	.....	.....	.....	Uneasy.
6:35	68.99	72.95	.....	.....	.....	.....	.....	.....	Uneasy.
6:50	69.08	72.32	.....	.....	.....	.....	.....	.....	Quiet.
7:5	69.2	73.04	.....	.....	.....	.....	.....	.....	Whining.
7:20	69.88	72.77	72.68	127.81	28.6683	9.0675	65.9128	58.7114	
	68.42 (mean)	71.28 68.42	3.98 (gain)	491.74 0.1766	0.17665	0.1103	0.0715 (gain)	0.0238 (gain)	
		2.86 (gain)		491.9166					

7:30 A. M.—Rectal temperature 105°.

8:30 A. M.—Ate one-half a pound of raw liver.

9:55 A. M.—Rectal temperature 103°.1.

10:25 A. M.—Barometer 30.13.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks.
10:25 A. M.	66°.68	68°.36	67°.64	613.265	28.6727	7.074	.....	.....	Whining.
10:40	66.92	68.63	.....	.....	.....	.....	.....	.....	Whining.
10:55	66.29	68.84	.....	.....	.....	.....	.....	.....	Quiet.
11:10	67.46	69.08	.....	.....	.....	.....	.....	.....	Quiet.
11:25	67.55	69.26	.....	.....	.....	.....	.....	.....	Whining.
11:40	67.37	66.96	.....	.....	.....	.....	.....	.....	Whining.
11:55	67.55	69.75	.....	.....	.....	.....	.....	.....	
12:10 P. M.	67.64	70.06	.....	.....	.....	.....	.....	.....	
12:25	67.04	69.96	69.44	813.98	28.7403	8.00375			
	67.17 (mean)	68.99 67.17	1.8 (gain)	200.715 0.0676	0.0676	0.92975	(gain)	(gain)	
		1.82 (gain)		200.7826					

12:30 P. M.—Rectal temperature 104°.2.

April 10.

2:50 P. M.—Injected in external jugular vein twenty minims of foul pus mixed with water.

3:10 P. M.—Rectal temperature 104°.7. Barometer 30.09.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks.
3:40 P. M.	70°.64	71°.24	67°.88	867.115	28.7325	9.5745	65.9375	58.7171	Whining.
3:55	65.30	69.26	.....	.....	.....	.....	.....	.....	Quiet.
4:10	68.54	69.95	.....	.....	.....	.....	.....	.....	Quiet.
4:25	69.08	70.05	.....	.....	.....	.....	.....	.....	Quiet.
4:40	69.53	70.34	.....	.....	.....	.....	.....	.....	Quiet.
4:55	69.37	70.25	.....	.....	.....	.....	.....	.....	Quiet.
5:10	69.79	70.25	.....	.....	.....	.....	.....	.....	Quiet.
5:25	69.53	70.34	.....	.....	.....	.....	.....	.....	Quiet.
5:40	69.53	70.25	.....	.....	.....	.....	.....	.....	Quiet.
5:55	68.8	70.43	.....	.....	.....	.....	.....	.....	Quiet.
6:10	69.62	70.43	.....	.....	.....	.....	.....	.....	Whining.
6:25	68.99	70.64	.....	.....	.....	.....	.....	.....	Quiet.
6:40	68.45	70.64	.....	.....	.....	.....	.....	.....	Quiet.
6:55	67.57	70.76	.....	.....	.....	.....	.....	....	Quiet.
7:10	68.63	70.88	.....	.....	.....	.....	.....	.....	Quiet.
7:25	69.2	70.97	.....	.....	.....	.....	.....	.....	Quiet.
7:40	69.53	71.6	.....	.....	.....	.....	.....	.....	Quiet.
7:55	69.44	71.24	.....	.....	.....	.....	.....	.....	Quiet.
8:10	68.9	71.24	.....	.....	.....	.....	.....	.....	Quiet.
8:25	68.81	71.33	.....	.....	.....	.....	.....	.....	Quiet.
8:40	70.52	71.92	71.24	1370.365	28.9554	9.7727	66.0253	58.7716	Quiet.
	69.04 (mean)	70.67 69.04	3.36 (gain)	503.25 0.2229	0.2229	0.1982	0.0878 (gain)	0.0545 (gain)	
		1.63 (gain)		503.4729					

8:45 P. M.—Rectal temperature 103°.9.

9:5 P. M.—Dog ate one-half of a pound of raw liver.

April 10 and 11.

10 P. M.—Rectal temperature 103°.9. 10:30 P. M.—Barometer 30.04.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks.
10:45 P. M.	71°.42	70°.64	68°.225	444.30	28.9467	9.773	64.6339	63.8221	Whining.
11	70.52	70.88	.....	.....	.....	.....	.....	.....	Quiet.
11:15	70.25	70.64	.....	.....	.....	.....	.....	.....	Quiet.
11:30	70	70.64	.....	.....	.....	.....	.....	.....	Quiet.
11:45	69.88	71.06	.....	.....	.....	.....	.....	.....	Quiet.
12	69.7	79.97	.....	.....	.....	.....	.....	.....	Quiet.
12:15 A. M.	69.61	70.96	.....	.....	.....	.....	.....	.....	Quiet.
12:30	69.32	72 32	.....	.....	.....	.....	.....	.....	Quiet.
12:45	69.61	71.84	.....	.....	.....	.....	.....	.....	Quiet.
1	70.16	71.96	.....	.....	.....	.....	.....	.....	Quiet.
1:15	70.04	72.32	.....	.....	.....	.....	.....	.....	Quiet.
1:30	69.92	71.6	.....	.....	.....	.....	.....	.....	Quiet.
1:45	69.92	71.6	.....	.....	.....	.....	.....	.....	Quiet.
2	70.52	72.41	.....	.....	.....	.....	.....	.....	Quiet.
2:15	68.8	72.23	.....	.....	.....	.....	.....	.....	Quiet.
2:30	70	72.5	.....	.....	.....	.....	.....	.....	Quiet.
2:45	69.71	72.32	.....	.....	.....	.....	.....	.....	Quiet.
3	69.80	72.68	.....	.....	.....	.....	.....	.....	Quiet.
3:15	70.16	72.92	.....	.....	.....	.....	.....	.....	Quiet.
3:30	70.04	73.04	.....	.....	.....	.....	.....	.....	Quiet.
3:45	71.76	72.8	72.32	931.316	29.3596	10.0946	64.8162	63.9169	Quiet.
	70.05 (mean)	72.25 70.05	4 095 (gain)	487.016 0.4129	0.4129	0.3216	0.1823 (gain)	0.0948 (gain)	
		2.2 (gain)		487.4289					

4 A. M.—Rectal temperature 105°.

5 A. M.—Rectal temperature 104°.

April 11

5 A. M.—Barometer 29.9. Rectal temperature 104°.8.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks.
5:30 A. M.	70°.66	71°.42	68°.6	976.1929	29.3929	10.098	64.8162	63.9169	Quiet.
5:45	70.43	70.43	.....	.....	.....	.....	.....	.....	Quiet.
6	70.64	70.64	.....	.....	.....	.....	.....	.....	Quiet.
6:15	70.52	70.76	.....	.....	.....	.....	.....	.....	Quiet.
6:30	70.43	70.88	.....	.....	.....	.....	.....	.....	Quiet.
6:45	70.76	70.97	.....	.....	.....	.....	.....	.....	Quiet.
7	70.52	70.97	.....	.....	.....	.....	.....	.....	Quiet.
7:15	69.35	70.64	.....	.....	.....	.....	.....	.....	Whining very faintly.
7:30	69.79	71.06	.....	.....	.....	.....	.....	.....	Quiet.
7:45	69.79	70.97	.....	.....	.....	.....	.....	.....	Quiet.
8	70.25	71.24	.....	.....	.....	.....	.....	.....	Quiet.
8:15	70.52	71.51	.....	.....	.....	.....	.....	.....	Quiet.
8:30	70.16	71.33	.....	.....	.....	.....	.....	.....	Quiet.
8:45	69.32	70.43	.....	.....	.....	.....	.....	.....	Quiet.
9	70.43	71.84	.....	.....	.....	.....	.....	.....	Quiet.
9:15	70.	71.84	.....	.....	.....	.....	.....	.....	Whining faintly.
9:30	68.36	71.42	.....	.....	.....	.....	.....	.....	Quiet.
3:45	67.76	71.48	.....	.....	.....	.....	.....	.....	Quiet.
10	66.20	71.15	.....	.....	.....	.....	.....	.....	Quiet.
10:15	67.57	71.59	.....	.....	.....	.....	.....	.....	Quiet.
10:30	68.54	72.08	72.068	1475.34	29.5917	10.354	64.88	63.9924	Quiet.
	69.62 (mean)	71.17 69.62	3.468 (gain)	499.1471 01.988	0.1988	0.256	0.0638 (gain)	0.0755 (gain)	
		1.55 (gain)		499.3459					

10:45 A. M.—Rectal temperature 105°.4. 11 A. M.—Dog ate half a pound of raw liver eagerly.

11:20 A. M.—20 minims of stale pus injected into the jugular vein.

11:34 P. M.—Rectal temperature 107°.

12:31 P. M.—Rectal temperature 107°.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms)	Remarks.
12:31 P. M.	70°.34	70°.25	68°	683.09	29.5904	10.3513	64.8895	63.9924	Quiet.
12:45	70.64	71.72	.....	.....	.....	.....	.....	.....	Quiet.
1	70.88	71.06	.....	.....	.....	.....	.....	.....	Quiet.
1:15	70.76	71.42	.....	.....	.....	.....	.....	.....	Quiet.
1:30	70.97	71.06	.....	.....	.....	.....	.....	.....	Whining.
1:45	71.6	71.15	.....	.....	.....	.....	.....	.....	Quiet.
2	71.69	71.41	.....	.....	.....	.....	.....	.....	Quiet.
2:15	72.2	72.32	.....	.....	.....	.....	.....	.....	Quiet.
2:30	72.2	72.5	.....	.....	.....	.....	.....	.....	Quiet.
2:45	70.87	72.5	.....	.....	.....	.....	.....	.....	Quiet.
3	72.83	73.04	.....	.....	.....	.....	.....	.....	Quiet.
3:15	72.52	72.95	.....	.....	.....	.....	.....	.....	Quiet.
3:30	72.63	73.35	.....	.....	.....	.....	.....	.....	Quiet.
3:45	72.42	73.04	.....	.....	.....	.....	.....	.....	Quiet.
4	72.32	72.95	.....	.....	.....	.....	.....	.....	Quiet.
4:15	72.20	73.24	.....	.....	.....	.....	.....	.....	Quiet.
4:30	71.87	73.45	.....	.....	.....	.....	.....	.....	Quiet.
4:45	71.87	73.14	.....	.....	.....	.....	.....	.....	Quiet.
5	72.32	73.66	.....	.....	.....	.....	.....	.....	Quiet.
5:15	72.52	74.21	.....	.....	.....	.....	.....	.....	Quiet.
5:31	83.3	74.	72.68	1066.59	29.903	10.5424	65.0275	64.0525	Quiet.
	72.33 (mean)	72.49 72.33	4.68 (gain)	383.5 0.3126	0.3126	0.1911	0.138 (gain)	0.0601 (gain)	
		0.16 (gain)		383.8126					

5:40 P. M.—Rectal temperature 104°.15.

April 11.

6:30 P. M.—Barometer 29.67. Rectal temperature 104°.15.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks.
7:2 A.M.	73°.8	71°.24	67°.76	144.	29.9091	10.5434	65.0275	64.0525	Quiet.
7:15	72.93	71.33	.....	.....	.....	.....	.....	.....	Quiet.
7:30	72.72	71.51	.....	.....	.....	.....	.....	.....	Quiet.
7:45	72.08	71.33	.....	.....	.....	.....	.....	.....	Quiet.
8	72.32	71.42	.....	.....	.....	.....	.....	.....	Quiet.
8:15	71.15	71.6	.....	.....	.....	.....	.....	.....	Quiet.
8:30	70.64	71.51	.....	.....	.....	.....	.....	.....	Quiet.
8:45	71.06	72.5	.....	.....	.....	.....	.....	.....	Quiet.
9	70.52	72.32	.....	.....	.....	.....	.....	.....	Quiet.
9:15	69.88	72.59	.....	.....	.....	.....	.....	.....	Quiet.
9:30	68.	72.8	.....	.....	.....	.....	.....	.....	Quiet.
9:45	68.	73.04	.....	.....	.....	.....	.....	.....	Quiet.
10	67.86	71.96	.....	.....	.....	.....	.....	.....	Quiet.
10:15	65.84	72.77	.....	.....	.....	.....	.....	.....	Quiet.
10:30	66.2	71.96	.....	.....	.....	.....	.....	.....	Quiet.
10:45	65.3	72.59	.....	.....	.....	.....	.....	.....	Quiet.
11	66.47	72.2	.....	.....	.....	.....	.....	.....	Quiet.
11:15	65.75	71.72	.....	.....	.....	.....	.....	.....	Quiet.
11:30	63.32	71.72	.....	.....	.....	.....	.....	.....	Quiet.
11:45	64.22	71.8	.....	.....	.....	.....	.....	.....	Quiet.
12:02 P. M.	65.3	72.86	72.32	618.302	30.1382	10.654	65.107	64.0947	Quiet.
	68.73 (mean)	72.04 68.73	4.56 (gain)	474.302 0.2291	0.2291	0.1106	0.0795 (gain)	0.0422 (gain)	
		3.31 (gain)		474.5311					

12:17 P. M.—Rectal temperature 105°.15.

April 12.

12:52 P. M.—Rectal temperature 105°.1.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)	Remarks.
1:41 P. M.	66°.08	69°.95	68°.09	737.27	30.1376	10.6525	65.1070	64.0947	Quiet.
1:56	67.64	69.95	.....	.....	.....	.....	.....	.....	Quiet.
2:11	67.64	71.12	.....	.....	.....	.....	.....	.....	Quiet.
2:26	67.04	70.43	.....	.....	.....	.....	.....	.....	Quiet.
2:56	67.37	70.25	.....	.....	.....	.....	.....	.....	Quiet.
3:11	68.81	70.97	.....	.....	.....	.....	.....	.....	Quiet.
3:26	68.89	71.42	.....	.....	.....	.....	.....	.....	Quiet.
3:41	69.44	71.42	.....	.....	.....	.....	.....	.....	Quiet.
3:56	64.4	69.96	.....	.....	.....	.....	.....	.....	Quiet.
4:11	64.13	69.75	.....	.....	.....	.....	.....	.....	Quiet.
4:26	64.76	69.54	.....	.....	.....	.....	.....	.....	Quiet.
4:41	64.31	69.75	.....	.....	.....	.....	.....	.....	Quiet.
4:56	63.32	69.44	.....	.....	.....	.....	.....	.....	Quiet.
5:11	65.96	70.43	.....	.....	.....	.....	.....	.....	Quiet.
5:26	66.68	70.25	.....	.....	.....	.....	.....	.....	Quiet.
5:41	66.8	70.43	.....	.....	.....	.....	.....	.....	Quiet.
5:56	67.04	70.64	.....	.....	.....	.....	.....	.....	Quiet.
6:11	66.56	71.24	.....	.....	.....	.....	.....	.....	Quiet.
6:26	66.38	70.64	.....	.....	.....	.....	.....	.....	Quiet.
6:41	66.08	70.34	71.78	1309.64	30.2641	10.7448	65.1475	64.1166	Quiet.
	66.47 (mean)	70.40 66.47	2.98 (gain)	572.37 0.1265	0.1265	0.0923	0.0405 (gain)	0.0219 (gain)	
		3.93 (gain)		572.4965					

6:50 P. M.—Rectal temperature 104°.6.

April 12.

9:30 A. M.—Rectal temperature 105°.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
9:42 A. M.	63°.41	67°.79	67°.513	285.41	30.264	10.7448	65.1475	64.1166
9:57	64.76	68.18						
10:12	64.31	68.						
10:27	64.76	68.36						
10:42	65.12	68.63						
10:57	64.49	69.08						
11:12	64.88	68.84						
11:27	65.3	69.35						
11:42	65.48	69.35						
11:57	65.21	69.54						
12:12 P. M.	65.57	69.54						
12:27	65.84	69.54						
12:42	65.96	69.65						
12:57	66.2	69.54	69.68	583.625	30.49136	10.8205	65.23	64.133
	65.09 (mean)	68.95 65.09	2.167 (gain)	298.215 0.2273	0.22736	0.0757	0.0825 (gain)	0.0164 (gain)
		3.86 (gain)		298.4423				

1:10 P. M.—Rectal temperature 104°.8.

April 13.

9 A. M.—Dog seems very ill; walks with great difficulty, and refuses to eat.

9 A. M.—Rectal temperature 105°.85.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
10:18 A. M.	62°.6	67°.59	65°.6	639.24
10:30	60.6	66.68		
10:45	63.05	66.68		
11	64.09	67.33		
11:15	64.64	67.69		
11:30	65.21	68.45		
11:45	65.57	68.53		
12 M.	65.84	68.27		
12:15 P. M.	66.36	68.96		
12:30	66.8	69.08		
12:45	65.48	68.		
1	65.84	68.45		
1:15	65.84	68.45		
1:30	65.96	69.08		
1:45	66.08	68.96		
2	66.56	69.44		
2:15	66.6	69.35		
2:30	67.37	69.85		
2:45	67.55	70.16		
3	68.12	70.16		
3:18	68.36	70.25	69.32	1070.694
	65.64 (mean)	68.64 65.64	3.72 (gain)	431.454
		3 (gain)		

3:25 P. M.—Rectal temperature 105°.85.

April 13.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft)
4:35 P. M.	69°.2	69°.44	66°.29	105.3
4:45	68.63	68.96		
5	68.54	69.17		
5:15	68.18	69.17		
5:30	67.46	69.08		
5:45	67.28	69.26		
6	66.8	69.26		
6:15	67.1	69.44		
6:30	66.56	69.55		
6:45	66.47	69.85		
7	66.29	69.85		
7:15	66.38	69.85		
7:30	66.29	69.75		
7:45	65.96	69.85		
8	65.57	69 85		
8:15	65.96	70.25		
8:30	65.57	70.06		
8:45	64.22	69.64		
9	66.08	71.43		
9:15	67.46	71.15		
9:35	67.64	71.15	70.565	536.741
	66.83 (mean)	69.81	4.275 (gain)	431.441
		66.83		
		2.98 (gain)		

9:45 P. M.—Rectal temperature 105°.4.

April 13 and 14.

10:30 P. M.—Rectal temperature 105°.4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter (cub. ft)
11 P. M.	62°.4	67°.79	65°.96	590.555
11:15	64.96	67.23		
11:30	64.09	67.79		
11:45	62.24	67.32		
12	62	67.02		
12:15 A. M.	63.23	68		
12:30	63.63	68.45		
12:45	63.41	68.45		
1	62.6	68.18		
1:15	62.36	68.09		
1:30	62.14	68.27		
1:45	61.8	68		
2	66.38	68.09		
2:15	61.5	68.27		
2:30	62.72	69.17		
2:45	62.36	69.08		
3	62.84	68.45		
3:15	62.24	68.45		
3:30	62.48	68.45		
3:45	62.1	68.54		
4	63.23	68.84	69.845	1041.48
	62.89 (mean)	68.19	3.885 (gain)	450.925
		62.89		
		5.3 (gain)		

4:15 A. M.—Rectal temperature 105°.

April 14.

4:45 A. M.—Rectal temperature 104°.9.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
5:7 A.M.	65°.03	69°.2	66°.2	1091
5:15	64.31	68.36		
5:30	64.04	68.09		
5:45	63.32	68		
6	62.36	67.8		
6:15	62.15	67.49		
6:30	62.06	68.27		
6:45	61.7	68		
7	61.75	69.44		
7:15	61.7	67.23		
7:30	62.6	65.48		
7:45	61.7	66.92		
8	61.5	66.47		
8:15	60.7	66.68		
8:30	61.6	66.47		
8:45	61.4	67.33		
9	61.3	67.23		
9:30	61.1	67.79		
9:45	61.8	68.18		
10:7	61.1	68	69.89	1506.5
	62.16 (mean)	67.62	3.69	415.5
		62.16		
		5.46 (gain)		

10:15 A. M.—Rectal temperature 104°.9.

April 16.—Dog alive and apparently better; eats; very lame.

Heat Dissipation.

First Period—

Quantity of air (V′) = 515.2536 at 70°.69 — 32° = 38.69 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{515.2536}{1.079} = 477.4$. $W = V \times 0.08073 = 38.6$

Rise in temp. of air 3.92 = t. $Q = W \times t \times$ sp. h. $= 38.6 \times 3.92 \times 0.2374 = 35.92$ = heat given to air.

Quotient for box $2159 \times 0.0883 = 190.6397$ = moisture leaving box.

Quotient for air $3488 \times 0.0261 = 91.0368$ = moisture entering box.

99.6029 = moisture vaporized in box.

$\frac{99.6029}{6.2789} = 15.86$ = heat expended in vaporization.

Rise in temp. of water $3.96 \times 164.1414 = 650$ = heat given to calorimeter.

35.92 = heat given to air.

15.86 = heat expended in vaporization.

701.78 = heat dissipated in 5 hours.

Hourly dissipation of heat 140.36

Second Period—

Quantity of air (V′) = 469.9 at 69°.83 — 32° = 37.83 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{469.9}{1.077} = 436.3$. $W = V \times 0.08073 = 35.22$

Rise in temp. of air 3.54 = t. $Q = W \times t \times$ sp. h. $= 35.22 \times 3.54 \times 0.2374 = 29.5987$ = heat given to air.

Quotient for box $1797 \times 0.1013 = 182.0361$ = moisture leaving box.

Quotient for air $2955 \times 0.0334 = 98.697$ = moisture entering box.

83.3391 = moisture vaporized in box.

$\frac{83.3391}{6.2789} = 13.2744$ = heat expended in vaporization.

Rise in temp. of water $3.13 \times 164.1414 = 513.7626$ = heat given to calorimeter.

29.5987 = heat given to air.

13.2744 = heat expended in vaporization.

556.6357 = heat dissipated in 5 hours.

Hourly dissipation of heat 111.3271

Third Period—

Quantity of air (V′) = 491.9166 at 71°.28 — 32° = 39.28 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{491.9166}{1.08} = 455.478$. $W = V \times 0.08073 = 36.77$

Rise in temp. of air 2.86 = t. $Q = W \times t \times$ sp. h. $= 36.77 \times 2.86 \times 0.2374 = 24.9655$ = heat given to air.

Quotient for box 2403 × 0.0715 = 171.8145 = moisture leaving box.

Quotient for air 3847.5 × 0.0238 = 91.5905 = moisture entering box.

80.224 = moisture vaporized in box.

$\frac{80.224}{6.2789} = 12.774$ = heat expended in vaporization.

Rise in temp. of water 3.98 × 164.1414 = 653.283 = heat given to calorimeter.

24.9655 = heat given to air.

12.774 = heat expended in vaporization.

691.0225 = heat dissipated in 5 hours.

Hourly dissipation of heat 138.2045

Fourth Period—

Quantity of air (V′) = 200.7826 at 68°.99 — 32° = 36.99 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{200.7826}{1.075} = 186.7$. $W = V \times 0.08073 = 15.07$

Rise in temp. of air 1.82 = t. $Q = W \times t \times$ sp. h. $= 15.07 \times 1.82 \times 0.2374 = 6.511$ = heat given to air.

Quotient for box } Meter incorrectly read.
Quotient for air }

Rise in temp. of water 1.8 × 164.1414 = 295.4545 = heat given to calorimeter.

6.511 = heat given to air.

4.5 = heat expended in vaporization.*

306.4655 = heat dissipated in 2 hours.

Hourly dissipation of heat 153.2327

Fifth Period—

Quantity of air (V′) = 503.4729 at 70°.67 — 32° = 38.67 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{503.4729}{1.079} = 466.6$. $W = V \times 0.08073 = 37.67$.

Rise in temp. of air 1.63 = t. $Q = W \times t \times$ sp. h. $= 37.67 \times 1.63 \times 0.2374 = 14.5768$ = heat given to air.

Quotient for box 2258.7 × 0.0878 = 198.3139 = moisture leaving box.

Quotient for air 2540.2 × 0.0545 = 138.4409 = moisture entering box.

59.8730 = moisture vaporized in box.

$\frac{59.8730}{6.2789} = 9.534$ = heat expended in vaporization.

Rise in temp. of water 3.36 × 164.1414 = 551.5151 = heat given to calorimeter.

14.5768 = heat given to air.

9.534 = heat expended in vaporization.

575.6259 = heat dissipated in 5 hours.

Hourly dissipation of heat 115.1252

Sixth Period—

Quantity of air (V′) = 487.4289 at 72°.25 — 32° = 40.25 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{487.4289}{1.08} = 451.32$. $W = V \times 0.08073 = 36.43$

Rise in temp of air 2.2 = t. $Q = W \times t \times$ sp. h. $= 36.4 \times 2.2 \times 0.2374 = 19.03$ = heat given to air.

Quotient for box 1180.5 × 0.1823 = 215.205 = moisture leaving box.

Quotient for air 1415.6 × 0.0948 = 134 199 = moisture entering box.

81.006 = moisture vaporized in box.

$\frac{81.006}{6.2789} = 12.89$ = heat expended in vaporization.

Rise in temp of water 4.095 × 164.1414 = 672.159 = heat given to calorimeter.

19.03 = heat given to air.

12.89 = heat expended in vaporization.

704.079 = heat dissipated in 5 hours.

Hourly dissipation of heat 140.816

* In a case of accident like this, the heat gain or loss connected with moisture is estimated.

Seventh Period—

Quantity of air (V′) = 499.3459 at 71°.17 — 32° = 39.17 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{499.3459}{1.08} = 462.3$. $W = V \times 0.08073 = 37.32$

Rise in temp. of air 1.55 = t. $Q = W \times t \times$ sp. h. $= 37.32 \times 1.55 \times 0.2374 = 13.7326$ = heat given to air.
Quotient for box $2511.8 \times 0.0638 = 160.25$ = moisture leaving box.
Quotient for air $1950.6 \times 0.0755 = 147.27$ = moisture entering box.

12.98 = moisture vaporized in box.

$\frac{12.98}{6.2789} = 2.067$ = heat expended in vaporization.

Rise in temp. of water $3.468 \times 164.1414 = 569.2424$ = heat given to calorimeter.
13.7326 = heat given to air.
2.067 = heat given to vapor.

585.0420 = heat dissipated in 5 hours.
Hourly dissipation of heat 117.0084

Eighth Period—

Quantity of air (V′) = 383.8126 at 72°.49 — 32° = 40.49 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{383.8126}{1.082} = 354.7$. $W = V \times 0.08073 = 28.63$

Rise in temp. of air 0.16 = t. $Q = W \times t \times$ sp. h. $= 28.63 \times 0.16 \times 0.2374 = 1.0875$ = heat given to air.
Quotient for box $1227.8 \times 0.138 = 169.437$ = moisture leaving box.
Quotient for air $2008.4 \times 0.0601 = 120.7048$ = moisture entering box.

48.7322 = moisture vaporized in box.

$\frac{48.7322}{6.2789} = 7.759$ = heat expended in vaporization.

Rise in temp. of water $4.68 \times 164.1414 = 768.1817$ = heat given to calorimeter.
1.0875 = heat given to air.
7.759 = heat expended in vaporization.

777.0282 = heat dissipated in 5 hours.
Hourly dissipation of heat 155.4056

Ninth Period—

Quantity of air (V′) = 474.5311 at 72°.04 — 32° = 40.04 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{474.5311}{1.08} = 439.38$. $W = V \times 0.08073 = 35.47$

Rise in temp. of air 3.31 = t. $Q = W \times t \times$ sp. h. $= 35.47 \times 3.31 \times 0.2374 = 27.87$ = heat given to air.
Quotient for box $2071.3 \times 0.0795 = 164.6683$ = moisture leaving box.
Quotient for air $4290.5 \times 0.0422 = 181.0591$ = moisture entering box.

16.3908 = moisture condensed in box.

$\frac{16.3908}{6.2789} = 2.61$ = heat gained from condensation.

Rise in temp. of water $4.56 \times 164.1414 = 748.4848$ = heat given to calorimeter.
27.87 = heat given to air.

776.3548
2.61 = heat gained from condensation.

773.7448 = heat dissipated in 5 hours.
Hourly dissipation of heat 154.7489

Tenth Period—

Quantity of air (V′) = 572.4965 at 70°.4 — 32° = 38.4 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{572.4965}{1.078} = 531$. $W = V \times 0.08073 = 42.87$

Rise in temp. of air 3.93 = t. $Q = W \times t \times$ sp. h. $= 42.87 \times 3.93 \times 0.2374 = 40$ = heat given to air.

Quotient for box 4525.7 × 0.0405 = 183.2908 = moisture leaving box.
Quotient for air 6202.5 × 0.0219 = 135.8347 = moisture entering box.

47.4561 = moisture vaporized in box.

$\frac{47.4561}{6.2789} = 7.557$ = heat gained from vaporization.

Rise in temp. of water 2.98 × 164.1414 = 489.1413 = heat given to calorimeter.
40 = heat given to air.
7.557 = heat expended in vaporization.

536.6983 = heat dissipated in 5 hours.
Hourly dissipation of heat 107.3396

Eleventh Period—

Quantity of air (V′) = 298.4423 at 68°.95 — 32° = 36.95 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{298.4423}{1.075} = 277.6$. $W = V \times 0.08073 = 22.41$

Rise in temp. of air 3.86 = t. $Q = W \times t \times$ sp. h. = 22.41 × 3.86 × 0.2374 = 20.54 = heat given to air.
Quotient for box 1316.2 × 0.0825 = 108.5865 = moisture leaving box.
Quotient for air 3942.2 × 0.0164 = 64.6520 = moisture entering box.

43.9345 = moisture vaporized in box.

$\frac{43.9345}{6.2789} = 6.99$ = heat gained from vaporization.

Rise in temp. of water 2.167 × 164.1414 = 355.794 = heat given to calorimeter.
20.54 = heat given to air.
6.99 = heat expended in vaporization.

383.324 = heat dissipated in $3\frac{1}{4}$ hours.
Hourly dissipation of heat 117.946

Twelfth Period—

Quantity of air (V′) = 431.454 at 68°.64 — 32° = 36.64 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{431.454}{1.074} = 401.7$. $W = V \times 0.08073 = 32.43$

Rise in temp. of air 3 = t. $Q = W \times t \times$ sp. h. = 32.43 × 3 × 0.2374 = 23.0966 = heat given to air.
Rise in temp. of water 3.72 × 164.1414 = 610.61 = heat given to calorimeter.
23.0966 = heat given to air.

633.706 = heat dissipated in 5 hours.
Hourly dissipation of heat 126.7412

Thirteenth Period—

Quantity of air (V′) = 431.441 at 69°.81 — 32° = 37.81 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{431.441}{1.077} = 400.6$. $W = V \times 0.08073 = 32.34$

Rise in temp. of air 2.98 = t′. $Q = W \times t \times$ sp. h. = 32.34 × 2.98 × 0.2374 = 22.879 = heat given to air.
Rise in temp. of water 4.275 × 164.1414 = 701.7045 = heat given to calorimeter.
22.879 = heat given to air.

724.5835 = heat dissipated in 5 hours.
Hourly dissipation of heat 144.9167

Fourteenth Period—

Quantity of air (V′) = 450.925 at 68°.19 — 32° = 36.19 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{450.925}{1.074} = 419.85$. $W = V \times 0.08073 = 33.89$

Rise in temp. of air 5.3 = t. $Q = W \times t \times$ sp. h. = 33.89 × 5.3 × 0.2374 = 42.6411 = heat given to air.
Rise in temp. of water 3.885 × 164.1414 = 637.6893 = heat given to calorimeter.
42.6411 = heat given to air.

680.3304 = heat dissipated in 5 hours.
Hourly dissipation of heat 136.066

Fifteenth Period—

Quantity of air (V′) = 415.5 at 67°.62 — 32° = 35.62 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{415.5}{1.072} = 387.6$. $W = V \times 0.08073 = 31.2909$

Rise in temp. of air 5.46 = t. $Q = W \times t \times$ sp. h. = 31.29 × 5.46 × 0.2374 = 40.5582 = heat given to air.

Rise in temp. of water 3.69 × 164.1414 = 605.6817 = heat given to calorimeter.
40.5582 = heat given to air.
646.2399 = heat dissipated in 5 hours.

Hourly dissipation of heat 129.2479

Heat Production.

First Period—

Rise of bodily temperature in 5 hours 1°.625, in 1 hour 0.325 = t.

$Q = W \times t \times$ sp. h. = 39 × 0.325 × 0.75 = 9.50625 = heat added to reserve.
140.36 = hourly dissipation of heat.
9.50625 = hourly addition to heat reserve.

Hourly production of heat 149.87

Second Period—

Rise of bodily temperature in 5 hours 0°.5, in 1 hour 0.1 = t.

$Q = W \times t \times$ sp. h. = 39 × 0.1 × 0.75 = 2.925 = heat added to reserve.
111.3271 = hourly dissipation of heat.
2.925 = hourly addition to heat reserve.

Hourly production of heat 114.2521

Third Period—

Rise of bodily temperature in 5 hours 0°.9565, in 1 hour 0.1913 = t.

$Q = W \times t \times$ sp. h. = 39 × 0.1913 × 0.75 = 5.5575 = heat added to reserve.
138.2045 = hourly dissipation of heat.
5.5575 = hourly addition to heat reserve.

Hourly production of heat 143.762

Fourth Period—

Rise of bodily temperature in 2 hours 0°.85, in 1 hour 0.43 = t.

$Q = W \times t \times$ sp. h. = 39 × 0.43 × 0.75 = 12.58 = heat added to reserve.
153.2327 = hourly dissipation of heat.
12.58 = hourly addition to heat reserve.

Hourly production of heat 165.8127

Fifth Period—

Fall of bodily temperature in 5 hours 0°.7165, in 1 hour 0.14 = t.

$Q = W \times t \times$ sp. h. = 39 × 0.14 × 0.75 = 4.095 = heat taken from reserve.
115.1252 = hourly dissipation of heat.
4.095 = hourly loss from heat reserve.

Hourly production of heat 111.0302

Sixth Period—

Rise of bodily temperature in 5 hours 0°.915, in 1 hour 0.18 = t.

$Q = W \times t \times$ sp. h. = 39 × 0.18 × 0.75 = 5.265 = heat added to reserve.
140.816 = hourly dissipation of heat.
5.265 = hourly addition to heat reserve.

Hourly production of heat 146.081

Seventh Period—

Rise of bodily temperature in 5 hours 0°.545, in 1 hour 0.109 = t.
Q = W × t × sp. h. = 39 × 0.109 × 0.75 = 3.04 = heat added to reserve.
117.0084 = hourly dissipation of heat.
3.1882 = hourly addition to heat reserve.

Hourly production of heat 120.1966

Eighth Period—

Fall of bodily temperature in 5 hours 2°.767, in 1 hour 0.553 = t.
Q = W × t × sp. h. = 39 × 0.553 × 0.75 = 16.09 = heat taken from reserve.
155.4056 = hourly dissipation of heat.
16.1692 = hourly loss from heat reserve.

Hourly production of heat 139.5748

Ninth Period—

Rise in animal temperature in 5 hours 0°.865, in 1 hour 0.173 = t.
Q = W × t × sp. h. = 39 × 0.173 × 0.75 = 4.9725 = heat added to reserve.
154.7489 = hourly dissipation of heat.
5.0602 = hourly addition to heat reserve.

Hourly production of heat 159.8091

Tenth Period—

Fall of bodily temperature in 5 hours 0°.415, in 1 hour 0.083 = t.
Q = W × t × sp. h. = 39 × 0.083 × 0.75 = 2.4277 = heat taken from reserve.
107.3396 = hourly dissipation of heat.
2.4277 = heat taken from reserve.

Hourly production of heat 104.9119

Eleventh Period—

Fall of bodily temperature in $3\frac{1}{4}$ hours 0°.177, in 1 hour 0.055 = t.
Q = W × t × sp. h. = 39 × 0.055 × 0.75 = 1.60875 = heat taken from reserve.
117.946 = hourly dissipation of heat.
1.60875 = heat taken from reserve.

Hourly production of heat 116.337

Twelfth Period—

No change in bodily temperature.
Hourly dissipation of heat = *hourly production of heat* 126.7412.

Thirteenth Period—

Fall of bodily temperature in $6\frac{1}{3}$ hours 0°.45, in one hour 0.071 = t.
Q = W × t × sp. h. = 39 × 0.071 × 0.75 = 2.05 = heat taken from reserve.
144.9167 = hourly dissipation of heat.
2.0767 = heat taken from reserve.

Hourly production of heat 142.84

Fourteenth Period—

Fall of bodily temperature in 5 hours, 0°.32, in 1 hour 0.064 = t.
Q = W × t × sp. h. = 39 × 0.064 × 0.75 = 1.872 = heat taken from reserve.
136.066 = hourly dissipation of heat.
1.872 = heat taken from reserve.

Hourly production of heat 134.194

Fifteenth Period—

No change in bodily temperature.
Hourly dissipation of heat = *hourly production of heat* 129.2479

RECAPITULATION.

	Time.	Heat Dissipation.	Heat Production.	Rect. Temp. (Fah.)	Remarks.
First day. April 9, 1 P. M. to April 10, 1 P. M.	1:20 P. M. to 6:20 P. M.	140.36	149.87	102°.85 to 104°.7	No food since 6 P.M. day before.
	7:37 P. M. to 12:37 A. M.	111.3271	114.2521	103.9 to 104.4	
	2:20 A. M. to 7:20 A. M.	138.2045	143.762	103.9 to 105	Had 1½ lbs. raw liver at 6.40 P.M.
	10:25 A. M. to 12:25 P. M.	153.2327	165.8127	103.1 to 104.2	
At 2:50 P. M.—20 minims of foul pus injected into jugular vein.					
Second day. April 10, 3:30 P. M. to April 11, 3:30 P. M.	3:40 P. M. to 8:40 P. M.	115.1252	111.0302	104.7 to 103.9	
	10:45 P. M. to 3:45 A. M.	140.816	146.081	103.9 to 105.	Dog ate 1½ lbs. liver at 9:5 A.M.
	5:30 A. M. to 10:30 A. M.	117.0084	120.1966	104.8 to 105.4	
	12:30 P. M. to 3:30 P. M.	155.4056	139.5748	107 to 104.15	
11:20 P. M.—20 minims of pus injected. Dog ate ½ lb. of beef at 1 P. M.					
Third day. April 11, 3:30 P. M. to April 12, 3:30 P. M.	3:30 P. M. to 5:30 P. M.*	155.4056	139.5748	107 to 104.15	
	7:2 P. M. to 12:2 A. M.	154.7489	159.8091	104.15 to 105.15	
	1:41 A. M. to 6:41 A. M.	107.3396	104.9119	105.1 to 104.6	
	9:42 A. M. to 12:42 P. M.	117.946	116.337	105 to 104.8	
Fourth day. April 13, 10 A. M. to April 14, 10 A. M.	10:18 A. M. to 3:18 P. M.	126.7412	126.7412	105.85	Dog very sick; refuses food.
	4:35 P. M. to 9:35 P. M.	144.9167	142.84	105.85 to 105.4	
	11 P. M. to 4 A. M.	136.066	134.194	105.4 to 105	
	5:7 A. M. to 10:71 A. M.	129.2479	129.2479	104.9	

SUMMARY.

	Time in Calorimeter.	Average Hourly Heat Dissipation.	Average Hourly Heat Production.	Extremes of Rect. Temp. (Fah.)	Average Rect. Temp. (Fah.)
First day.	17 hours.	132.7014	139.4733	102°.85 to 105°	104°.07
Second day.	18 hours.	129.498	128.0702	103.9 to 105.4	104.78
Third day.	15 hours.	131.5025	130.1177	104.15 to 107	104:89
Fourth day.	20 hours.	134.243	133.256	104.9 to 105.85	105.39

Experiment 112.

A dog. Weight 19 pounds. Had been fed in the morning.

May 10. 12:13 P. M.—Rectal temperature 103°.3.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:13 A. M.	68°.36	71°.96	69°.56	753.38
12:28	67.28	71.84		
12:43	67.55	72.2		
12:58	67.55	71.96		
1:13	68.24	71.24		
1:28	67.76	71.96		
1:43	68.72	71.72		
1:58	68.81	71.84		
2:13	69.08	72.08		
2:28	69.02	72.41		
2:43	69.62	72.5		
2:58	69.8	72.86		
3:13	69.44	72.5		
3:28	69.71	72.86		
3:43	70.04	72.95		
3:58	70.16	73.14		
4:13	70.43	73.45		
4:28	71.56	73.66	72.23	1088.65
	69.06 (mean)	72.79	2.67 (gain)	335.27
		69.06		
		3.73 (gain)		

4:28 P. M.—Rectal temperature 102°.5.

4:57 P. M.—Rectal temperature 103°.4.

* This period was obtained by taking average of period from 12:30 P. M. to 3:30 P. M.

May 10.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
5:11 P. M.	72°.53	74 .3	71°.36	104.88
5:26	71.51	74.3		
5:41	71.84	73.76		
5:56	71.72	74.12		
6:11	71.84	74.12		
6:26	72.6	74.12		
6:41	71.24	73.45		
6:56	70.52	74.21		
7:11	70.25	74.12		
7:26	70.25	74.21		
7:41	69.92	73 45		
7:56	69.71	73.45		
8:11	69.62	73.55		
8:26	68.72	73.45		
8:41	68.72	73.35		
8:56	68.8	73.35		
9:11	68.9	73.25		
9:26	67.76	72.95		
9:41	68.36	73.33		
9:56	68.72	73.55		
10:11	69.20	73.55	73.445	445.52
	70.13 (mean)	73.71 70.13	2.085 (gain)	340.64
		3.58 (gain)		

10:30 P. M.—Rectal temperature 103°.3.

May 10 and 11.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:3 P. M.	65°.64	70°.64	71°	510.695
11:18	65.96	71.72		
11:33	65.21	72.5		
11:48	64.13	71.6		
12:3 A. M.	65	72.2		
12:18	64.67	71.72		
12:33	65	72.32		
12:48	64.67	72.59		
1:3	64.4	72.08		
1:18	64.4	72.8		
1:33	65.12	72.59		
1:48	65.12	72.68		
2:3	66.68	72.95		
2:18	68.36	73.88		
2:33	69.33	74.39		
2:48	68.99	73.66		
3:3	67.28	72.77		
3:18	67.28	72.86		
3:33	67.37	72.95		
3:48	68.36	73.04		
4:3	68.81	73.04	73.418	859.55
	66.275 (mean)	72.62 66.275	2.418 (gain)	348.855
		6.345 (gain)		

4:15 A. M.—Rectal temperature 102°.8.

May 11.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
5 A. M.	67°.76	71°.06	70°.592	906.55
5:15	65.66	71.06		
5:30	69.29	71.24		
5:45	65.39	71.15		
6	64.22	70.43		
6:15	64.22	70.43		
6:30	62.15	69.75		
6:45	62.15	69.44		
7	62.15	69.54		
7:15	62.15	70.25		
7:30	63.68	70.97		
7:45	63.92	70.06		
8	63.32	70.43		
8:15	63.05	70.43		
8:30	62.87	70.34		
8:45	62.87	70.06		
9	63.05	69.96		
9:15	63.23	70.52		
9:30	63.5	70.43		
9:45	63.41	70.97		
10	63.68	69.65	72.725	1251.7
	63.89 (mean)	70.44 63.89	2.133 (gain)	345.15
		6.55 (gain)		

10:24 A. M.—Rectal temperature 102°.8.

4:20 P. M.—Rectal temperature 103°.7.

4:30 P. M.—Twenty minims of putrid blood (six days old) injected into the jugular vein.

4:35 P. M.—Dog vomiting.

4:50 P. M.—Rectal temperature 104°.3.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
4:57 P. M.	65°.66	65°.96	66°.056	261.7
5:12	66.38	66.68		
5:27	68.54	68.63		
5:42	67.76	68		
5:57	66.28	68.47	66.92	339.45
	66.92 (mean)	67.55 66.92	0.864 (gain)	77.75
		0.63 (gain)		

6:5 P. M.—Rectal temperature 102°.6.

May 11.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
6:21 P. M.	65°.66	.....	66°.29	364.65
6:36	62.24	67°.33		
6:51	62.6	67.13		
7:5	63.32	66.56		
7:20	63.05	66.8		
7:35	63.14	66.92		
7:50	62.48	67.33		
8:5	62.24	67.33		
8:20	61.7	67.33		
8:35	61.6	67.04		
8:50	61.4	66.8		
9:5	61.4	66.68		
9:20	61.3	67.79		
9:35	59.7	67.13		
9:50	62.1	66.37		
10:5	62.1	67.43		
10:20	62.2	67.49		
10:35	62.2	67.59		
10:50	62.15	67.59		
11:15	63.68	67.8		
11:21	.....	68	68.48	719.1
	62.31 (mean)	67.22	2.19 (gain)	354.45
		62.31		
		4.91 (gain)		

11:30 P. M.—Rectal temperature 104°.3.

May 12.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:13 A. M.	63°.23	65°.03	66°.965	734.8
12:30	63.8	66.38		
12:45	64.31	67.79		
1	63.23	67.49		
1:15	64.88	68.45		
1:30	65	68.45		
1:45	65.48	68.63		
2	65.66	69.35		
2:15	65.84	69.65		
2:30	66.2	69.95		
2:45	66.29	69.45		
3	66.08	69.95		
3:15	65.98	70.25		
3:30	65.86	69.85		
3:45	66.08	69.54		
4	66.08	69.64		
4:15	66.29	69.85		
4:30	66.29	69.75		
4:45	66.2	69.75		
5	66.08	69.75		
5:13	64.67	68.75	69.26	1060
	65.41 (mean)	68.9	2.295 (gain)	325.2
		65.41		
		3.49 (gain)		

5:30 A. M.—Rectal temperature 104°.

May 12.

6 A. M.—Rectal temperature 104°.5.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
6:18 A. M.	66°.29	69°.08	66°.56	113.7
6:30	66.38	68.63		
6:45	67.9	65.96		
7	62.	67.43		
7:15	62.2	67.23		
7:30	62.	66.56		
7:45	61.7	66.47		
8	61.8	66.8		
8:15	61.9	66.8		
8:30	61.4	66.38		
8:45	61.9	66.08		
9	60.5	66.08		
9:15	60.3	66.64		
9:30	60.3	66.56		
9:45	60.3	66.47		
10	60.3	66.65		
10:15	60.4	66.92		
10:30	60.4	66.84		
10:45	61.	67.59		
11	61.1	67.02		
11:18	.....	.....	68.225	449.72
	62.00 (mean)	66.91	1.665 (gain)	336.02
		62.00		
		4.91 (gain)		

11:30 A. M.—Rectal temperature 104°.3. Dog refuses to eat.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:13 P. M.	62°.15	66°.47	66°.716	507.915
12:28	61.15	66.56		
12:43	61.	66.68		
12:58	60.1	66.92		
1:13	60.1	66.92		
1:28	60.1	66.2		
1:43	60.1	66.29		
1:58	60.1	66.47		
2:13	60.1	66.29		
2:28	60.1	65.84		
2:43	60.	65.39		
2:58	59.5	66.47		
3:13	59.2	65.72		
3:28	60.	66.56		
3:43	59.6	67.02		
3:58	60.3	67.02		
4:13	.....	.....	68.09	891.61
	60.22 (mean)	66.43	1.374 (gain)	383.695
		60.22		
		6.21 (gain)		

4:15 P. M.—Rectal temperature 106°.5.

May 12.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
4:38 P. M.	63°.41	65°.6	66°.56	817.67
4:53	63.23	66.38		
5:8	63.8	68.09		
5:23	63.59	67.23		
5:38	63.8	67.79		
5:53	64.04	67.89		
6:8	62.24	66.38		
6:23	61.2	66.8		
6:38	61.	67.23		
6:53	59.2	66.29		
7:8	58.6	65.84		
7:23	59.	63.38		
7:38	59.6	68.09		
7:53	60.7	67.43		
8:8	61.4	67.02		
8:23	61.7	67.33		
8:38	61.7	67.53		
8:53	62.	68.09		
9:8	62.69	68.18		
9:23	62.51	68.27		
9:38	.....	.....	68.9	1134.27
	61.77 (mean)	67.04	2.34 (gain)	316.60
		61.77		
		5.27 (gain)		

9:45 P. M.—Rectal temperature 106°.

May 12 and 13.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
10:5 P. M.	64°.4	68°.45	67°.1	156.79
10:20	63.8	68.45		
10:35	64.04	68.84		
10:50	63.92	69.85		
11:5	64.04	68.96		
11:20	64.13	68.96		
11:35	64.22	69.08		
11:50	64.04	69.08		
12:5 A. M.	64.13	69.72		
12:20	64.04	69.96		
12:35	63.8	69.26		
12:50	63.8	69.32		
1:5	63.8	69.44		
1:20	63.44	69.44		
1:35	63.44	69.75		
1:50	63.44	69.35		
2:5	63.40	69.35		
2:20	63.32	69.17		
2:35	62.72	69.44		
2:50	62.48	69.54		
3:5	62.72	69.54		
3:20	62.6	69.75		
3:35	62 96	69.75		
3:50	63.14	70.06		
4:5	.....	.....	70.88	518.86
	63.57 (mean)	69.31	3.78 (gain)	362.07
		63.57		
		5.74 (gain)		

4:16 A. M.—Rectal temperature 104°.5.

May 13.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
4:36 A. M.	63°.23	67°.49	67 .28	550.3
4:51	63.23	67.49		
5:6	63.23	67.43		
5:21	62.75	68.		
5:36	62.15	67.02		
5:51	62.15	65.21		
6:6	61.6	64.26		
6:21	62.	63.9		
6:36	61.7	68.27		
5:51	62.1	67.79		
7:6	62.1	68.54		
7:21	62.36	68.63		
7:36	62.72	68.27		
7:51	62.84	68.27		
8:6	62.84	68.45		
8:21	62.72	68.36		
8:36	62.72	68.96		
8:51	62.72	69.08		
9:6	63.05	69.54		
9:21	63.14	69.35		
9:36	.....	.....	69.8	855.14
	62.56 (mean)	67.71 62.56	2.52 (gain)	304.84
		5.15 (gain)		

9:45 A. M.—Rectal temperature 104°.1

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
10:13 A. M.	63°.59	66°.65	66°.176	893.6
10:28	62.84	67.02		
10:43	63.68	67.69		
10:58	62.6	67.13		
11:13	63.23	66.92	66.8	958.39
	63.19 (mean)	67.08 63.19	0.624 (gain)	64.79
		3.89 (gain)		

11:15 A. M.—Rectal temperature 104°.3.

11:32 A. M.—Dog etherized, and the spinal cord cut between the last cervical and the first dorsal vertebræ.

11:38 A. M.—Rectal temperature 104°.6.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:55 A. M.	63°.23	66°.29	64°.94	969.32
12:10 P. M.	62.72	66.38		
12:25	62.6	66.47		
12:40	62.48	66.47		
12:50	63.32	66.49	65.72	1037.12
	62.87 (mean)	66.42 62.87	0.78 (gain)	67.80
		3.55 (gain)		

1:21 P. M.—Rectal temperature 94°.

Heat Dissipation.

First Period—

Quantity of air (V′) = 335.27 at 72°.39 — 32° = 40.39 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{335.27}{1.083} = 309.6$. $W = V \times 0.08073 = 25$

Rise in temp. of air 3.33 = t. $Q = W \times t \times$ sp. h. $= 25 \times 3.33 \times 0.2374 = 19.7636$ = heat given to air.
Rise in temp. of water $2.67 \times 130.8589 = 349.3932$ = heat given to calorimeter.
19.7636 = heat given to air.
369.157 = dissipation of heat in $4\frac{1}{4}$ hours.
Hourly dissipation of heat 86.86

Second Period—

Quantity of air (V′) = 340.64 at 73°.71 — 32° = 41.71 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{340.64}{1.085} = 313.9$. $W = V \times 0.08073 = 25.34$

Rise in temp. of air 3.58 = t. $Q = W \times t \times$ sp. h. $= 25.34 \times 3.58 \times 0.2374 = 21.536$ = heat given to air.
Rise in temp. of water $2.085 \times 130.8589 = 272.8408$ = heat given to calorimeter.
21.536 = heat given to air.
294.3768 = dissipation of heat in 5 hours.
Hourly dissipation of heat 58.8753

Third Period—

Quantity of air (V′) = 348.855 at 72°.62 — 32° = 40.62 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{348.855}{1.083} = 322.1$. $W = V \times 0.08073 = 26$

Rise in temp. of air 6.345 = t. $Q = W \times t \times$ sp. h. $= 26 \times 6.345 \times 0.2374 = 39.16$ = heat given to air.
Rise in temp. of water $2.418 \times 130.8589 = 316.4168$ = heat given to calorimeter.
39.16 = heat given to air.
355.5768 = dissipation of heat in 5 hours.
Hourly dissipation of heat 71.1153

Fourth Period—

Quantity of air (V′) = 345.15 at 70°.44 — 32° = 38.44 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{345.15}{1.078} = 320.1$. $W = V \times 0.08073 = 25.84$

Rise in temp. of air 6.55 = t. $Q = W \times t \times$ sp. h. $= 25.84 \times 6.55 \times 0.2374 = 40.18$ = heat given to air.
Rise in temp. of water $2.133 \times 130.8589 = 279.122$ = heat given to calorimeter.
40.18 = heat given to air.
319.302 = dissipation of heat in 5 hours.
Hourly dissipation of heat 63.86

Fifth Period—

Quantity of air (V′) = 77.75 at 67°.55 — 32° = 35.55 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{77.75}{1.07} = 72.66$. $W = V \times 0.08073 = 5.866$

Rise in temp. of air 0.63 = t. $Q = W \times t \times$ sp. h. $= 5.866 \times 0.63 \times 0.2374 = 0.877$ = heat given to air.
Rise in temp. of water $0.864 \times 130.8589 = 113.062$ = heat given to calorimeter.
0.877 = heat given to air.
Hourly dissipation of heat 113.939

Sixth Period—

Quantity of air (V′) = 354.45 at 67.22° — 32° = 35.22 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{354.45}{1.07} = 331.2$. $W = V \times 0.08073 = 26.74$

Rise in temp. of air 4.91 = t. Q = W × t × sp. h. = 26.74 × 4.91 × 0.2374 = 31.169 = heat given to air.
Rise in temp. of water 2.19 × 130.8589 = 286.5810 = heat given to calorimeter.
31.169 = heat given to air.
317.75 = dissipation of heat in 5 hours.
Hourly dissipation of heat 63.55

Seventh Period—

Quantity of air (V′) = 325.2 at 68°.90 — 32° = 36.90 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{325.2}{1.075} = 302.5$. $W = V \times 0.08073 = 24.42$

Rise in temp. of air 3.49 = t. Q = W × t × sp. h. = 25.17 × 3.49 × 0.2374 = 21.8548 = heat given to air.
Rise in temp. of water 2.295 × 130.8589 = 300.3212 = heat given to calorimeter.
21.8548 = heat given to air.
321.1765 = dissipation of heat in 5 hours.
Hourly dissipation of heat 64.4353

Eighth Period—

Quantity of air (V′) = 336.02 at 66°.91 — 32° = 34.91 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{336.02}{1.07} = 314$. $W = V \times 0.08073 = 25.35$

Rise in temp. of air 4.91 = t. Q = W × t × sp. h. = 25.35 × 4.91 × 0.2374 = 29.549 = heat given to air.
Rise in temp. of water 1.665 × 130.8589 = 217.88 = heat given to calorimeter.
31.774 = heat given to air.
249.654 = heat dissipated in 5 hours.
Hourly dissipation of heat 49.93

Ninth Period—

Quantity of air (V′) = 383.695 at 66°.43 — 32° = 34.43 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{383.695}{1.07} = 358.6$. $W = V \times 0.08073 = 28.95$

Rise in temp. of air 6.21 = t. Q = W × t × sp. h. = 28.95 × 6.21 × 0.2374 = 42.68 = heat given to air.
Rise in temp. of water 1.374 × 130.8589 = 179.8001 = heat given to calorimeter.
42.68 = heat given to air.
222.4801 = heat dissipated in 5 hours.
Hourly dissipation of heat 44.5

Tenth Period—

Quantity of air (V′) = 316.6 at 67°.04 — 32° = 35.04 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{316.6}{1.07} = 295.9$. $W = V \times 0.08073 = 23.89$

Rise in temp. of air 5.27 = t. Q = W × t × sp. h. = 23.89 × 5.27 × 0.2374 = 29.8886 = heat given to air.
Rise in temp. of water 2.34 × 130.8589 = 306.2098 = heat given to calorimeter.
29.8886 = heat given to air
336.0984 = heat dissipated in 5 hours.
Hourly dissipation of heat 67.2197

Eleventh Period-

Quantity of air (V′) = 362.07 at 69°.31 — 32° = 37.31 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{362.07}{107.6} = 336.5$. $W = V \times 0.08073 = 27.16$

Rise in temp. of air 5.74 = t. Q = W × t × sp. h. = 27.16 × 5.74 × 0.2374 = 37.01 = heat given to air.
Rise in temp. of water 3.78 × 130.8589 = 494.6466 = heat given to calorimeter.
37.01 = heat given to air.
531.6566 = heat dissipated in 5 hours.
Hourly dissipation of heat 106.3313

Twelfth Period—

Quantity of air (V′) = 304.84 at 67°.71 — 32° = 35.71 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{304.84}{1.07} = 284.9$. $W = V \times 0.08073 = 23$

Rise in temp. of air 5.15 = t. $Q = W \times t \times$ sp. h. = 23. × 5.15 × 0.2374 = 28.12 = heat given to air.
Rise in temp. of water 2.52 × 130.8589 = 329.7644 = heat given to calorimeter.
28.12 = heat given to air.

357.8844 = heat dissipated in 5 hours.

Hourly dissipation of heat 71.5769

Thirteenth Period—

Quantity of air (V′) = 64.79 at 67°.08 — 32° = 35.08 = t′.

$V + (V \times t' \times 0.002035) = V$. $V = \frac{64.79}{1.07} = 60.5$. $W = V \times 0.08073 = 4.88$

Rise in temp. of air 3.89 = t. $Q = W \times t \times$ sp. h. = 4.88 × 3.89 × 0.2374 = 4.5066 = heat given to air.
Rise in temp. of water 0.624 × 130.8589 = 81.6559 = heat given to calorimeter.
4.5066 = heat given to air.

Hourly dissipation of heat 86.1625

Fourteenth Period—

Quantity of air (V′) = 67.8 at 66°.42 — 32° = 34.42 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{67.8}{1.07} = 63.4$. $W = V \times 0.08073 = 5.12$

Rise in temp. of air 3.55 = t. $Q = W \times t \times$ sp. h. = 5.12 × 3.55 × 0.2374 = 4.06 = heat given to air.
Rise in temp. of water 0.78 × 130.8589 = 102.0699 = heat given to calorimeter.
4.06 = heat given to air

106.1299 = heat dissipated in 55 minutes.

Hourly dissipation of heat 115.778

Heat Production.

First Period—

Fall of bodily temperature in $4\frac{1}{4}$ hours 0°.8, in 1 hour 0.19 = t.
$Q = W \times t \times$ sp. h. = 19 × 0.19 × 0.75 = 2.701 = heat taken from reserve.
86.86 = hourly dissipation of heat.
2.701 = hourly loss from heat reserve.

Hourly production of heat 84.159

Second Period—

Fall of bodily temperature in $5\frac{2}{3}$ hours 0°.1, in 1 hour 0.018 = t.
$Q = W \times t \times$ sp. h. = 19 × 0.018 × 0.75 = 0.2566 = heat taken from reserve.
58.8753 = hourly dissipation of heat.
0.2566 = hourly loss from heat reserve.

Hourly production of heat 58.6187

Third Period—

Fall of bodily temperature in $5\frac{3}{4}$ hours 0°.5, in 1 hour 0.087 = t.
$Q = W \times t \times$ sp. h. = 19 × 0.087 × 0.75 = 1.2397 = heat taken from reserve.
71.1153 = hourly dissipation of heat.
1.2397 = hourly loss from heat reserve.

Hourly production of heat 69.8756

Fourth Period—

No change of bodily temperature.
Heat dissipated hourly = *hourly production of heat* 63.799

26 July, 1880.

Fifth Period—

Fall of bodily temperature in 2 hours 1°.7, in 1 hour 0.85 = t.
Q = W × t × sp. h. = 19 × 0.85 × 0.75 = 12.11 = heat taken from reserve.
113.939 = hourly dissipation of heat.
12.11 = hourly loss from heat reserve.

Hourly production of heat 101.829

Sixth Period—

Rise of bodily temperature in 5¼ hours 1°.7, in 1 hour 0.314 = t.
Q = W × t × sp. h. = 19 × 0.314 × 0.75 = 4.617 = heat added to reserve.
63.55 = hourly dissipation of heat.
4.474 = hourly addition to heat reserve.

Hourly production of heat 68.024

Seventh Period—

Fall of bodily temperature in 6 hours 0°.3, in 1 hour 0.05 = t.
Q = W × t × sp. h. = 19 × 0.05 × 0.75 = 0.7125 = heat taken from reserve.
64.2342 = hourly dissipation of heat.
0.7125 = hourly loss from heat reserve.

Hourly production of heat 63.5217

Eighth Period—

Fall of bodily temperature in 5½ hours 0°.2, in 1 hour 0.036 = t.
Q = W × t × sp. h. = 19 × 0.036 × 0.75 = 0.513 = heat taken from reserve.
49.93 = hourly dissipation of heat.
0.513 = heat taken from reserve.

Hourly production of heat 49.417

Ninth Period—

Rise of bodily temperature in 4¾ hours 2° 2, in 1 hour 0.463 = t.
Q = W × t × sp. h. = 19 × 0.463 × 0.75 = 6.5977 = heat added to reserve.
44.5 = hourly dissipation of heat.
6.5977 = hourly addition to reserve.

Hourly production of heat 51.0977

Tenth Period—

Fall of bodily temperature in 5½ hours 0°.5, in 1 hour 0.091 = t.
Q = W × t × sp. h. = 19 × 0.091 × 0.75 = 1.2967 = heat taken from reserve.
67.2197 = hourly dissipation of heat.
1.2967 = heat taken from reserve.

Hourly production of heat 65.923

Eleventh Period—

Fall of bodily temperature in 6½ hours 1°.5, in 1 hour 0.231 = t.
Q = W × t × sp. h. = 19 × 0.231 × 0.75 = 3.2917 = heat taken from reserve.
106.3313 = hourly dissipation of heat.
3.2917 = heat taken from reserve.

Hourly production of heat 103.0396

Twelfth Period—

Fall of bodily temperature in 5½ hours 0°.4, in 1 hour 0.073 = t.
Q = W × t × sp. h. = 19 × 0.073 × 0.75 = 1.040 = heat taken from reserve.
71.5769 = hourly dissipation of heat.
1.04 = heat taken from reserve.

Hourly production of heat 70.5369

Thirteenth Period—

Rise in bodily temperature in 1.5 hours 0°.2, in 1 hour 0.1333 = t.

Q = W × t × sp. h. 19 × 0.1333 × 0.75 = 1.8995 = heat added to reserve.

86.1625 = hourly dissipation of heat.
1.8995 = heat added to reserve.

Hourly production of heat 88.062

Fourteenth Period—

Fall of bodily temperature in 1⅔ hours 10°.6, in 1 hour 6.36 = t.

Q = W × t × sp. h. 19 × 6.36 × 0.75 = 90.63 = heat taken from reserve.

90.63 = heat taken from reserve.
115.778 = hourly dissipation of heat.

Hourly production of heat 25.148

RECAPITULATION.

Day.	Time.	Hourly Heat Dissipation.	Hourly Heat Production.	Rect. Temp. (Fah.)	Remarks.
First day. May 10, 12 noon, to May 11, 12 noon.	12:13 P. M. to 4:28 P. M.	86.86	84.159	103°.3 to 102°.5	Dog had been fed in the morning.
	5:11 P. M. to 10:11 P. M.	58.8753	58.6187	104.3 to 103.3	
	11:3 P. M. to 4:3 A. M.	71.1153	69.8756	103.3 to 102.8	
	5 A. M. to 10 A. M.	63.799	63.799	102.8	
Second day. May 11, 4 P. M. to May 12, 4 P. M.	4:57 P. M. to 5:57 P. M.	113.939	101.829	104.3 to 102.6	
	6:21 P. M. to 11:21 P. M.	63.551	68.024	102.6 to 104.3	
	12:13 A. M. to 5:13 A. M.	64.2342	63.5217	104.3 to 104	
	6:18 A. M. to 11:18 A. M.	49.93	49.417	104.5 to 104.3	Dog refuses to eat.
Third day. May 12, 11:30 A. M. to May 13, 11:30 A. M.	12:13 P. M. to 4:13 P. M.	44.5	51.0977	104.3 to 106.5	
	4:38 P. M. to 9:38 P. M.	67.2197	65.923	106.5 to 106	
	10:5 P. M. to 4:5 A. M.	106.3313	103.0396	106 to 104.5	
	4:36 A. M. to 9:36 A. M.	71.5769	70.5369	104.5 to 104.1	
	10:13 A. M. to 11:13 A. M.	86.1625	88.062	104.1 to 104.3	
Cord cut.	11:55 A. M. to 12:50 A. M.	115.778	25.148		

In this case a fever day for contrasting with normal day is best obtained by taking from 12:13 A. M., May 11, to 12:13 P. M., May 12.

SUMMARY.

	Time in Calorimeter.	Average Hourly Heat Dissipation.	Average Hourly Heat Production.	Extremes of Rect. Temp. (Fah.)	Average Rect. Temp. (Fah.)
First day.	19¼ hours.	69.5117	68.059	102°.5 to 104°.3	103°.4
Second day.	16 hours.	62.66	62.9151	102.6 to 104.5	104.2
Third day.	21 hours.	76.006	75.8566	104.1 to 106.5	105.2

Experiment 113.

A dog. Weight 22 pounds; had been fed in the morning of experiment.

May 14. 5:10 P. M.—Rectal temperature 103°.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
5:30 P. M.	63°.23	67°.02	63°.32	111.41	100	100.023	72.727	72.011
5:45	62.96	67.02						
6	62.04	67.12						
6:15	63.23	67.43						
6:30	63.14	67.69						
6:45	63.14	67.9						
7	62.24	67.9						
7:15	62.36	67.8						
7:30	61.36	67 49						
7:45	59	65.96						
8	60.3	66.47						
8:15	59.3	66.29						
8:30	59.3	66.8						
8:45	59	66.47						
9	68.7	67.13						
9:15	58.7	66.8						
9:30	59.9	68.45						
9:45	59.8	68.27						
10	61.2	68.96						
10:15	61.2	69.08						
10:30	61.51	68.84						
10:45	61.72	68.45						
11	61.2	68.18						
11:15	61.3	68.09						
11:30	61.5	68.09						
11:45	.....	.....	68.42	519.75	100.3196	100.2847	72.7795	72.0625
	61.09 (mean)	67.59	5.1 (gain)	408.34	0.3196	0.2617	0.0525 (gain)	0.0515 (gain)
		61.09		0.3196				
		6.5 (gain)		408.6596				

May 15. 12 midnight.—Rectal temperature 103°. 1 A. M.—Rectal temperature 102°.6.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
1:34 A. M.	67°.28	69°.54	64°.76	669.8	100.3197	100.282	72.795	72.0625
1:50	67.37	69.64						
2:5	67.46	71.15						
2:20	63.5	69.44						
2:35	63.8	69.35						
2:50	65.48	69.54						
3:5	66.21	69.44						
3:20	65.21	69.54						
3:35	62.05	69.75						
3:50	65.75	69.44						
4:5	63.92	68.36						
4:20	62.34	68.27						
4:35	62:14	68.54						
4:50	62.14	68.09						
5:5	60.14	67.32						
5:20	59.1	67.02						
5:35	58.9	66.65						
5:50	58.8	66.47						
6:5	59	66.92						
6:20	58.7	67.02						
6:35	60.9	68.18						
6:50	56.8	65.84						
7:5	55.6	65.12						
7:20	57	66.8						
7:34	59.6	68.84	68.576	977.925	100.667	100.6742	72.8832	72.1291
	61.97 (mean)	68.25	3.816 (gain)	308.125	0.3473	0.3922	0.0882 (gain)	0.0666 (gain)
		61.97		0.3473				
		6.28 (gain)		308.4723				

8 A. M.—Rectal temperature 102°.8. 9:30 A. M.—Dog given about three ounces of bread.

11:20 A. M.—Rectal temperature 102°.

May 15.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
11:25 A. M.	61°.44	65°.84	63°.68	1045.9	100.667	100.6472	72.8832	68.5954
11:40	61.64	66.29						
11:55	63.8	67.02						
12:10 P. M.	62.84	66.38						
12:25	61.64	65.84						
12:40	61.94	66.08						
12:55	61.64	66.47						
1:10	62.72	66.47						
1:25	62.48	65.23						
1:40	63.23	66.8						
1:55	63.04	66.56						
2:10	63.32	67.02						
2:25	63.68	67.32						
2:40	63.92	67.32						
2:55	63.32	67.23						
3:10	63.32	67.23						
3:25	63.92	67.9						
3:40	64.13	67.43						
3:55	64.4	67.69						
4:10	65.3	67.49						
4:25	.....	.....	66.8	1434	100.7832	100.825	72.9078	68.6436
	63.08 (mean)	66.78 63.08	3.12 (gain)	388.1 0.1162	0.1162	0.1778	0.0246 (gain)	0.0482 (gain)
		3.7 (gain)		388.2162				

4:30 P. M.—Rectal temperature 102°.2.

4:40 P. M.—Dog ate half a pound of raw liver.

5:30 P. M.—Injected into the jugular vein twenty minims of blood, eleven days old.

May 16, 10:30 A. M.—Rectal temperature 103°.6. Dog seems very quiet and sick, injected ten minims of blood, four and a half days old.

12:20 P. M.—Rectal temperature 104°.8.

May 16.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
12:35 P. M.	.....	.....	64°.76	488.9	0.8	0.8245	72.9078	75.9576
12:50	59°.5	65°.48						
1:5	59.4	65.21						
1:20	60.1	66.39						
1:35	60.3	65.39						
1:50	60.7	65.48						
2:5	61.24	66.65						
2:20	61.6	67.02						
2:35	62.14	67.12						
2:50	62.84	68.09						
3:5	63.29	68						
3:20	63.68	68.63						
3:35	64.22	68.27						
3:50	64.4	68.54						
4:5	.....	.....	67.055	709.8	.....	.....	72.9444	76.0344
	61.8 (mean)	66.94 61.8	2.295 (gain)	220.9			0.0366 (gain)	0.0768 (gain)
		5.14 (gain)						

4:20 P. M.—Rectal temperature 103°.6.

May 16.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
4:36 P. M.	.....	.....	65°.255	754.65	.....	.....	72.9444	76.1344
4:51	66 .68	68°.54						
5:6	66.17	68.63						
5:21	66.68	69.26						
5:36	66.68	69.35						
5:51	66.29	69.26						
6:6	66 92	69.85						
6:21	66.47	69.64						
6:36	66.77	69.26						
6:51	65.21	69.35						
7:6	64.67	69.17						
7:21	64.04	69.08						
7:36	64.04	69.75						
7:51	64.49	69.85						
8:6	64.67	69.75						
8:21	63.23	69.85						
8:36	62.96	70.06						
8:51	63.32	69.85						
9:6	63.59	69.85						
9:21	64.31	69.95						
9:36	61.9	69.95						
9:51	61.1	70.16						
10:6	61.8	69.75						
10:21	60 4	69.64						
10:36	.....	.....	69.704	1233.2	101.228	101.209	72.9991	76.1627
	64.46 (mean)	69.55 64.46	4.449 (gain)	478.55			0.0547 (gain)	0.0283 (gain)
		5.09 (gain)						

10:45 P. M.—Rectal temperature 103°.8.

11:55 P. M.—Rectal temperature 103°.4.

May 17.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
12:26 A. M.	60°.6	67°.79	66°.47	291.02	101.228	101.209	72.9991	76.1627
12:40	60.	68						
12:55	59.1	66.92						
1:10	59.2	66.38						
1:25	61.48	66.29						
1:40	60.1	68.12						
1:55	60.3	68.84						
2:10	58.7	67.43						
2:25	59	67.79						
2:40	59.2	68.54						
2:55	60.1	68.54						
3:10	59.7	68.72						
3:25	59.3	68.45						
3:40	59.3	68.29						
3 55	59.4	68.2						
4:10	59.7	69.06						
4:25	59.1	68.63						
4:40	58.7	68.27						
4:55	58.9	68.72						
5:10	58.9	68.84						
5:26	62.6	69.44	69.08	727.8	101.3104	101.425	73.021	76.1935
	59.68 (mean)	68.15 59.68	2.61 (gain)	436.78 0.0824	0.0824	0.216	0.0219 (gain)	0.0308 (gain)
		8.47 (gain)		436.8624				

5:55 A. M.—Rectal temperature 103°.4.

May 17. 9:50 A. M.—Dog very quiet; does not seem very sick. Rectal temperature 103°.9.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
10:8 A. M.	65°.3	68°.18	65°.6	823.4	101.3104	101.425	73.021	76.1935
10:23	66.38	68.36						
10:38	65.57	69.17						
10:53	65.66	68.84						
11:8	.....	.....	66.47	919.045	101.3371		73.0221	76.1982
	65.73 (mean)	68.64 65.73	0.87 (gain)	95.645 0.0267	0.0267		0.0011 (gain)	0.0047 (gain)
	2.91 (gain)			95.6717				

11:10 A. M.—Rectal temperature 103°.7.

11:50 A. M.—Dog ate one pound of raw beef.

12:15 P. M.—40 minims of blood, 5½ days old, injected into the jugular vein.

3:30 P. M.—Rectal temperature 104°.8. 30 minims of blood injected into the jugular vein.

4:15 P. M.—Rectal temperature 106°.7.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
4:32 P. M.	.....	.....	63°.86	1072.92	101.3337	101.4275	73.0221	76.1982
4:47	61°.94	66°.29						
5:2	61.24	66.29						
5:17	61	66.64						
5:32	60.7	66.38						
5:47	61	66.8						
6:2	60.4	67.13						
5:17	60.4	66.01						
6:32	64.22	69.36						
6:47	64.31	69.65						
7:2	66.56	70.43						
7:17	68.9	71.24						
7:32	70.07	72.05						
7:47	70.64	72.14						
8:2	70.06	72.32						
8:17	67.04	71.42						
8:32	63.8	70.34						
8:47	64.76	70.06						
9:2	62.72	69.96						
9:17	63.05	70.16						
9:32	63.44	71.61						
9:47	61.84	71.06						
10:2	61.64	70.61						
10:17	62.14	71.15						
10:32	62.02	70.97	68.99	1487.24	101.4911	101.6416	73.035	76.2482
	63.91 (mean)	69.58 63.91	5.13 (gain)	414.32 0.1574	0.1574	2.2141	0.0129 (gain)	0.05 (gain)
		5.67 (gain)		414.4774				

10:45 P. M.—Rectal temperature 104°.7.

May 17 and 18.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
11:32 P. M.	67°.28	68°.96	66°.47	511.72	101.4925	101.6425	73.035	76.2482
11:47	63.68	70.61						
12:2 A. M.	59.8	68.24						
12:17	66.2	66.68						
12:32	67.28	70.97						
12:47	68.81	71.33						
1:2	64.22	72.59						
1:17	68.81	71.15						
1:32	70.16	72.41						
1:47	70	72.96						
2:2	71.24	74						
2:17	71.33	74.12						
2:32	71.84	74.12						
2:47	72.32	74.21						
3:2	72.08	73.45						
3:17	72.83	74 3						
3:32	72.63	74.57						
3:47	72.73	74.48						
4:2	72.73	74.56						
4:17	72.78	74.56						
4:32	71.69	74.84						
4:47	69.80	73.88						
5:2	68.99	73.45						
5:17	67.76	73.45						
5:32	67.1	72.8						
5:47	66.38	71.72						
6:2	65.39	71 96						
6:17	64.76	71.72						
6:32	.....	.....	72.41	1023.575	101.7	101.771	73.132	76.281
	68.7 (mean)	72.57 68.7	5.94 (gain)	511.855 0.2117	0.2117	0.1285	0.097 (gain)	0.0328 (gain)
		3.87 (gain)		512.0667				

6:40 A. M.—Rectal temperature 104°.8.

10:40 A. M.—Rectal temperature 104°.1.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	General Meter. (cub. ft.)	Sample Meter. (cub. ft.)	Air Meter. (cub. ft.)	Sample Calcium Tube. (grms.)	Air Calcium Tube. (grms.)
10:51 A.M.	67°.76	70°.06	66°.515	1078.37	101.7118	101.7704	73.132	76.281
11:6	67.1	70.06						
11:21	66.44	70.64						
11:36	66.68	70.43						
11:51	67.28	71.51						
12:6 P. M.	66.68	70.97						
12:21	67.37	70.64						
12:36	66.47	71.15						
12:51	.....	.....	68.18	1251.75	101.7852	101.8055	73.1529	76.2893
	66.97 (mean)	70.68 66.97	1.665 (gain)	173.38 0.0734	0.0734	0.0351	0.0209 (gain)	0.0083 (gain)
		3.71 (gain)		173.4534				

1:10 P. M.—Rectal temperature 104°.1.

1:5 P. M.—Spinal cord cut between the upper dorsal and the first cervical vertebræ. Complete palsy of the hind legs.

May 18. 1:13 P. M.—Rectal temperature 104°.3.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:24 P. M.	.....	.....	65°.864	288.25
1:39	68°.63	70°.25		
1:54	69.08	69.44		
2:9	69.71	71.24		
2:24	69 53	71.15		
2:39	70.04	71 06		
2:54	70.64	70.97	67.532	400.82
	69.6 (mean)	70.68	1.668 (gain)	112.57
		69.6		
		1.08 (gain)		

2:55 P. M.—Rectal temperature 90°.8.

Heat Dissipation.

First Period—

Quantity of air (V′) = 408.6596 at 67°.59 — 32° = 35.59 = t′

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{408.6596}{1.0724} = 381.1$. $W = V \times 0.08073 = 30.8$

Rise in temp. of air 6.5 = t. $Q = W \times t \times$ sp. h. $= 30.8 \times 6.5 \times 0.2374 = 47.5275$ = heat given to air.
Quotient for box $1278.6 \times 0.0525 = 67.1265$ = moisture leaving box.
Quotient for air $1561.5 \times 0.0515 = 80.4172$ = moisture entering box.

13.2907 = moisture condensed in box.

$\frac{13.2907}{6.2768} = 2.1174$ = heat gained from condensation.

Rise in temp. of water $5.1 \times 130.8589 = 667.3804$ = heat given to calorimeter.
47.5275 = heat given to air.
714.9079
2.1174 = heat gained from condensation.
712.7905 = heat dissipated in $6\frac{1}{4}$ hours.
Hourly dissipation of heat 114.0465

Second Period—

Quantity of air (V′) = 308.4723 at 68°.25 — 32° = 36.25 = t.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{308.4723}{1.074} = 287$. $W = V \times 0.08073 = 23.17$

Rise in temp. of air 6.28 = t. $Q = W \times t \times$ sp. h. $= 23.17 \times 6.28 \times 0.2374 = 34.539$ = heat given to air.
Quotient for box $888.2 \times 0.0882 = 78.3392$ = moisture leaving box.
Quotient for air $786.5 \times 0.0666 = 52.3809$ = moisture entering box.

25.9583 = moisture vaporized in box.

$\frac{25.9583}{6.2768} = 4.1356$ = heat expended in vaporization.

Rise in temp. of water $3.816 \times 130.8589 = 499.3576$ = heat given to calorimeter.
34.539 = heat given to air.
4.1356 = heat expended in vaporization.
538.0322 = heat dissipated in 6 hours.
Hourly dissipation of heat 89.672

Third Period—

Quantity of air (V′) = 388.2162 at 66°.78 — 32° = 34.78 = t′.

$V + (V \times t' \times 0.002035) = V$. $V = \frac{388.2162}{1.071} = 362.5$. $W = V \times 0.08073 = 29.3$

Rise in temp. of air 3.7 = t. $Q = W \times t \times$ sp. h. $= 29.3 \times 3.7 \times 0.2374 = 25.7365$ = heat given to air.
Quotient for box $3340.9 \times 0.0246 = 82.1861$ = moisture leaving box.
Quotient for air $2183.4 \times 0.0482 = 105.239$ = moisture entering box.

23.0538 = moisture condensed in box.

27 July, 1880.

$\frac{23.0538}{6.2768}$ = 3.6729 = heat gained from condensation.

Rise in temp. of water 3.12 × 130.8589 = 408.2798 = heat given to calorimeter.
25.7365 = heat given to air.

434.0163
3.6729 = heat gained from condensation.

430.3434 = heat dissipated in 5 hours.

Hourly dissipation of heat 86.0687

Fourth Period—

Quantity of air (V′) = 220.9 at 66°.94 — 32° = 34.94 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{220.9}{1.071} = 206.1$ $W = V \times 0.08073 = 16.66$

Rise in temp. of air 5.14 = t. $Q = W \times t \times$ sp. h. = 16.66 × 5.14 × 0.2374 = 20.3291 = heat given to air.
Rise in temp. of water 2.295 × 130.8589 = 300.3212 = heat given to calorimeter.
20.3291 = heat given to air.

320.6503 = heat dissipated in 3½ hours.

Hourly dissipation of heat 91.6144*

Fifth Period—

Quantity of air (V′) = 478.55 at 69°.55 — 32° = 37.55 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{478.55}{1.076} = 447.$ $W = V \times 0.08073 = 35.9$

Rise in temp. of air 5.09 = t. $Q = W \times t \times$ sp. h. = 35.9 × 5.09 × 0.2374 = 40.9826 = heat given to air.
Rise in temp. of water 4.449 × 130.8589 = 582.1912 = heat given to calorimeter.
40.9826 = heat given to air.

623.1738 = heat dissipated in 6 hours.

Hourly dissipation of heat 103.8623*

Sixth Period—

Quantity of air (V′) = 436.8624 at 68°.15 — 32° = 36.15 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{436.8624}{1.073} = 407.1.$ $W = V \times 0.08073 = 32.8$

Rise in temp. of air 8.47 = t. $Q = W \times t \times$ sp. h. = 32.8 × 8.47 × 0.2374 = 65.9535 = heat given to air.
Quotient for box 5301.7 × 0.0219 = 116.1072 = moisture leaving box.
Quotient for air 2022.5 × 0.0308 = 62.293 = moisture entering box.

53.8142 = moisture vaporized in box.

$\frac{53.8142}{6.2768} = 8.5735$ = heat expended in vaporization.

Rise in temp. of water 2.61 × 130.8589 = 341.5417 = heat given to calorimeter.
65.9535 = heat given to air.
8.5735 = heat expended in vaporization.

416.0687 = heat dissipated in 5 hours.

Hourly dissipation of heat 83.2137

Seventh Period—

Quantity of air (V′) = 95.6717 at 68°.64 — 32° = 36.64 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{95.6717}{1.075} = 89.$ $W = V \times 0.08073 = 7.185$

Rise in temp. of air 2.91 = t. $Q = W \times t \times$ sp. h. = 7.185 × 2.91 × 0.2374 = 4.9636 = heat given to air.
Rise in temp. of water 0.87 × 130.8589 = 113.8472 = heat given to calorimeter.
4.9636 = heat given to air.

Hourly dissipation of heat 118.8108*

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* The sample meters in these heats were not read through an inadvertency, and consequently the moisture could not be calculated; the moisture account had varied so in contiguous periods of the experiments that it was deemed safest to make no attempt at an average.

Eighth Period—

Quantity of air (V′) = 414.4774 at 69°.58 — 32° = 37.58 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{414.4774}{1.076} = 385.2$. $W = V \times 0.08073 = 31.1$

Rise in temp. of air 5.67 = t. $Q = W \times t \times$ sp. h. $= 31.1 \times 5.67 \times 0.2374 = 41.8624$ = heat given to air.

Quotient for box $2633.3 \times 0.0129 = 33.9696$ = moisture leaving box.

Quotient for air $1935.9 \times 0.05 = 96.795$ = moisture entering box.

62.8254 = moisture condensed in box.

$\frac{62.8254}{6.2768} = 10.0091$ = heat gained from condensation.

Rise in temp. of water $5.13 \times 130.8589 = 671.3061$ = heat given to calorimeter.

41.8624 = heat given to air.

713.1685

10.0091 = heat gained from condensation.

703.1594 = heat dissipated in 6 hours.

Hourly dissipation of heat 117.1932

Ninth Period—

Quantity of air (V′) = 512.0667 at 72°.57 — 32° = 40.57 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{512.0667}{1.082} = 473.2$. $W = V \times 0.08073 = 38.2$

Rise in temp. of air 3.87 = t $Q = W \times t \times$ sp. h. $= 38.2 \times 3.87 \times 0.2374 = 35.0958$ = heat given to air.

Quotient for box $2418.8 \times 0.097 = 234.6236$ = moisture leaving box.

Quotient for air $3985 \times 0.0328 = 130.708$ = moisture entering box.

103.9156 = moisture vaporized in box.

$\frac{103.9156}{6.2768} = 16.5555$ = heat expended in vaporization.

Rise in temp. of water $5.94 \times 130.8589 = 777.3019$ = heat given to calorimeter.

35.0958 = heat given to air.

16.5555 = heat expended in vaporization.

828.9532 = heat dissipated in 7 hours.

Hourly dissipation of heat 118.4219

Tenth Period—

Quantity of air (V′) = 173.453 at 70°.68 — 32° = 38.68 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{173.453}{1.079} = 160.7$. $W = V \times 0.08073 = 13$

Rise in temp. of air 3.71 = t. $Q = W \times t \times$ sp. h. $= 13 \times 3.71 \times 0.2374 = 11.4498$ = heat given to air.

Quotient for box $2363 \times 0.0209 = 49.3867$ = moisture leaving box.

Quotient for air $4941.7 \times 0.0083 = 41.0161$ = moisture entering box.

8.3706 = moisture vaporized in box.

$\frac{8.3706}{6.2768} = 1.3336$ = heat expended in vaporization.

Rise in temp. of water $1.665 \times 130.8589 = 217.88$ = heat given to calorimeter.

11.4498 = heat given to air.

1.3336 = heat expended in vaporization.

230.664 = heat dissipated in 2 hours.

Hourly dissipation of heat 115.3317

Eleventh Period—

Quantity of air (V′) = 112.57 at 70°.68 — 32° = 38.68 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{112.57}{1.079} = 104.3$. $W = V \times 0.08073 = 8.42$

Rise in temp. of air 1.08 = t. $Q = W \times t \times$ sp. h. $= 8.42 \times 1.08 \times 0.2374 = 2.1588$ = heat given to air.

Rise in temp. of water $1.668 \times 130.8589 = 218.2726$ heat given to calorimeter.

2.1588 heat given to air.

220.4314 = heat dissipated in $1\frac{1}{2}$ hours.

Hourly dissipation of heat 146.9542*

* Moisture not calculated.

Heat Production.

First Period—

No change of bodily temperature.
Hourly dissipation of heat = *hourly production of heat* 114.0465

Second Period—

Fall of bodily temperature in 7 hours 0°.2, in 1 hour 0.029 = t.
Q = W × t × sp. h. = 22× 0.029 × 0.75 = 0.4785 = heat taken from reserve.
89.672 = hourly dissipation of heat.
0.4785 = hourly loss from heat reserve.

Hourly production of heat 89.1935

Third Period—

Rise of bodily temperature in 5 hours 0°.2, in 1 hour 0.04 = t.
Q = W × t × sp. h. = 22 × 0.04 × 0.75 = 0.66 = heat added to reserve.
86.0687 = hourly dissipation of heat.
0.66 = hourly addition to heat reserve.

Hourly production of heat 86.7287

Fourth Period—

Fall of bodily temperature in 4 hours 1°.2, in 1 hour 0.3 = t.
Q = W × t × sp. h. = 22 × 0.3 × 0.75 = 4.95 = heat added to reserve.
91.6144 = hourly dissipation of heat.
4.95 = hourly loss from heat reserve.

Hourly production of heat 86.6644

Fifth Period—

Rise of bodily temperature in 6 hours 0°.2, in 1 hour 0.033 = t.
Q = W × t × sp. h. = 22 × 0.033 × 0.75 = 0.5445 = heat taken from reserve.
103.8623 = hourly dissipation of heat.
0.5445 = hourly addition to heat reserve.

Hourly production of heat 104.4068

Sixth Period—

No alteration of bodily temperature.
Hourly dissipation of heat = *hourly production of heat* 83.2137

Seventh Period—

Fall of bodily temperature in $1\frac{1}{4}$ hours 0.2, in 1 hour 0.16 = t.
Q = W × t × sp. h. = 22 × 0.16 × 0.75 = 2.64 = heat taken from reserve.
118.8108 = hourly dissipation of heat.
2.64 = hourly loss from heat reserve.

Hourly production of heat 116.1708

Eighth Period—

Fall of bodily temperature in $6\frac{1}{2}$ hours 2°, in 1 hour 0.308 = t.
Q = W × t × sp. h. = 22 × 0.308 × 0.75 = 5.082 = heat taken from reserve.
117.1932 = hourly dissipation of heat.
5.082 = hourly loss from heat reserve.

Hourly production of heat 112.1112

Ninth Period—

Rise of bodily temperature in 8 hours 0°.1, in 1 hour 0.0125 = t.
Q = W × t × sp. h. = 22 × 0.0125 × 0.75 = 0.2062 = heat added to reserve.

118.4208 = hourly dissipation of heat.
0.2062 = hourly addition to heat reserve.

Hourly production of heat 118.627

Tenth Period—

No change of bodily temperature.
Heat dissipated hourly = *hourly production of heat* 115.3317

Eleventh Period—

Fall of bodily temperature in 102 minutes 13°.5, in 1 hour 7.941 = t.
Q = W × t × sp. h. = 22 × 7.941 × 0.75 = 131.0265 = heat taken from reserve.

146.9542 = hourly dissipation of heat.
131.0265 = hourly loss from heat reserve.

Hourly production of heat 15.9277

RECAPITULATION.

	Time.	Heat Dissipation.	Heat Production.	Rect. Temp. (Fah.)	Remarks.
First day.	5:30 P. M. to 11:45 P. M.	114.0465	114.0465	103°	Dog had been fed
May 14, 5 P. M. to	1:34 A. M. to 7:34 A. M.	89.6720	89 1935	102.6 to 102.8	early in the morn-
May 15, 5 P. M.	11:25 A. M. to 4:25 P. M.	86.0687	86.7287	102 to 102.2	ing.

4:40 P. M.—Dog ate ½ lb. raw liver. 5:30 P. M. injected into jugular 20 minims putrid blood. May 16, 11 A. M. 10 minims more.

Second day.	12:35 P. M. to 4:5 P. M.	91.6144	86.6644	104.8 to 103.6
May 16, 12.30 P. M. to	4:36 P. M. to 10:36 P. M.	103.8623	104.4068	103.6 to 103.8
May 17, 12.30 P. M.	12:26 A. M. to 5:26 A. M.	83.2137	83.2137	103.4
	10:8 A. M. to 11:8 A. M.	118.8108	116.1708	103.9 to 103.7

11:50 P. M.—Dog ate 1 lb. raw beef. Injected into jugular 40 minims of putrid blood.

Third day.	4:32 P. M. to 10:32 P. M.	117.1932	112.1112	106.7 to 104,7
May 17, 4.30 P. M. to	11:32 P. M. to 6:32 A. M.	118.4219	118.627	104.7 to 104.8
May 18, 1 P. M.	10:51 A. M. to 12:51 P. M.	115.3317	115.3317	104.1

After section of cord.

1:24 P. M. to 2:54 P. M.	146.9542	15.9277	104.3 to 90.8

SUMMARY.

	Time in Calorimeter.	Average Hourly Heat Dissipation.	Average Hourly Heat Production.	Extremes of Rect. Temp. (Fah.)	Average Rect. Temp. (Fah.)
First day.	17¼ hours.	97.4589	97.4838	102.2 to 103	102.6
Second day.	14½ hours.	95.4002	94.3229	103.4 to 104.8	103.7
Third day.	15 hours	117.5184	115.5817	104.1 to 106.7	105

Experiment 114.

A cur. Weight 25 pounds.

June 4. 8 A. M.—Dog ate three-quarters of a pound of cooked beef's liver.

11:53 A. M.—Rectal temperature 102°.6.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:53 A.M.	.....	.....	69°.92	45
12:30 P.M.	69°.17	72°.2		
12:45	68.99	72.32		
1	70.04	72.41		
1:15	70.64	73.45		
1:30	71.15	73.55		
1:45	71.51	73.88		
2	72.08	74.12		
2:15	72.42	74.57		
2:30	72.42	74.57		
2:45	72.73	74.57		
3	72.89	74.96		
3:15	72.99	74.96		
3:30	73.4	74.96		
3:45	73.85	75.47		
4	73.94	75.28		
4:15	73.94	74.96		
4:30	74.48	75.09		
4:45	74.93	75.56		
5	75.02	75.56		
5:15	75.02	75.56		
5:30	75.65	75.68		
5:53	.....	.....	74.03	600.504
	72.73 (mean)	74.46	4.11 (gain)	555.504
		72.73		
		1.73 (gain)		

5:53 P. M.—Rectal temperature 103°.6.

6:15 P. M.—Dog ate ten ounces of cooked mutton.

6:30 P. M.—Rectal temperature 102°.4.

Time.	Air Temp (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
6:47 P. M.	.....	.....	73°.09	1053.5
7	71°.96	75°.38		
7:15	73.1	75.38		
7:35	74.12	74.96		
7:55	73.85	74.96		
8:15	73.52	75.2		
8:35	73.4	74.66		
8:55	73.3	74.66		
9:15	73.3	74.48		
9:35	73.1	74.84		
9:55	73.09	75.38		
10:15	73.19	75.38		
10:35	73.19	75.47		
10:55	72.53	75.56		
11:15	72.42	75.56		
11:35	73.09	75.68		
11:47	.....	.....	76.16	1524.6
	73.14 (mean)	75.17	3.07 (gain)	471.1
		73.14		
		2.03 (gain)		

12:10 A. M.—Rectal temperature 102°.2.

12:30 A. M.—Dog ate four ounces of cooked meat.

June 5.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:45 A. M.	.....	.....	74°.21	565.63
1:15	70°.43	75°.92		
1:35	70.97	75.92		
1:55	71.78	75.68		
2:15	72.32	75.92		
2:35	72.08	75.92		
2:55	71.42	76.04		
3:15	71.78	76.04		
3:35	71.87	76.16		
3:55	71.6	76.28		
4:15	71.33	76.16		
4:35	70.88	76.04		
4:55	70.43	75 92		
5:15	70.64	75.92		
5:35	70.88	76.28		
5:55	70.97	76.28		
6:15	71.33	76.46		
6:35	71.33	76.91		
6:45	.....	.....	77.27	1164.6
	71.3 (mean)	76.11	3.06 (gain)	598.97
		71.3		
		4.81 (gain)		

7 A. M.—Rectal temperature 101°.4.

8 A. M.—Dog ate three ounces of cooked meat.

8:30 A. M.—Rectal temperature 101°.2.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
8:48 A. M.	.....	.....	71°.96	172.06
9:30	71°.33	74°		
9:50	72.08	74.56		
10:10	72.32	74.88		
10:30	72.52	74.12		
10:50	72.73	74.57		
11:10	72.83	74.48		
11:30	72.89	74.75		
11:48	.....	.....	73.769	447
	72.39 (mean)	74.48	1.809 (gain)	274.94
		72.39		
		2.09 (gain)		

12 noon.—Rectal temperature 101°.9

5 P. M.—Dog has had no food since the three ounces of meat at 8 A. M. No food given during the following twenty-four hours.

8 P. M.—Rectal temperature 101°.3.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
8:15 P. M.	.....	.....	69°.32	511.37
8:45	63°.32	69°.85		
9	65.3	69.54		
9:20	64.31	69.08		
9:40	63.68	68.96		
10	63.5	68.63		
10:20	62.87	68.72		
10:40	62.24	68.84		
11	62.14	68 45		
11:26	61.74	68.63		
11:45	61.14	68.55	70.43	831.54
	63.02 (mean)	68.92	1.11 (gain)	320.17
		63.02		
		5.9 (gain)		

12 midnight.—Rectal temperature 101°.8.

June 6.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter (cub. ft.)
12:47 A. M.	.....	.....	67°.46	901.3
1:20	60°.1	66°.08		
1:40	59.4	65.3		
2	59.1	65.21		
2:20	59.3	65.18		
2:40	59.3	65.72		
3	58.1	66.68		
3:20	57.8	65.09		
3:40	58.9	67.23		
4	58.6	67.33		
4:20	57.1	65.84		
4:40	57.3	66.56		
5	57.1	66.47		
5:20	56.1	66.08		
5:40	56.9	66.29		
6	56.5	66.08		
6:20	57.8	66.68		
6:47	.....	.....	69.32	1400
	58.09 (mean)	66.11	1.86 (gain)	498.7
		58.09		
		8.02 (gain)		

6:50 A. M.—Rectal temperature 101°.8.

8:20 A. M.—Rectal temperature 101°.4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
8:50 A. M.	.....	.....	66°.263	400.67
9:20	60°.6	65°.30		
9:40	59.8	66.29		
10	60.04	67.43		
10:20	59.9	67.33		
10:40	61.24	67.23		
11	62.24	67.23		
11:20	62.6	67.9		
11:40	62.72	67.69		
12 M.	62.96	67.69		
12:20 P. M.	63.23	68		
12:40	63.32	68		
1	63.5	68.18		
1:20	63.15	68.45		
1:40	64.13	68.54		
2	64.49	68.96		
2:20	64.76	69.44	68.54	914.85
	62.41 (mean)	67.73	2.277 (gain)	514.18
		62.41		
		5.32 (gain)		

2:20 P. M.—Rectal temperature 101°.

June 6. 3:37 P. M.—Rectal temperature 100°.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:37 P. M.	.....	.....	68°.036	983
4	64°.76	69°.96		
4:20	68.45	69.26		
4:40	68.54	70.64		
5	68.54	70.52		
5:20	68.72	70.88		
5:40	68.99	70.52		
6	69.08	70.88		
6:20	68.9	71.06		
6:40	69.44	71.6		
7	68.81	70.52		
7:25	68.45	70.52		
7:37	.....	.....	70.16	1310.75
	68.43 (mean)	70.58	2.124 (gain)	327.75
		68.43		
		2.15 (gain)		

7:37 P. M.—Rectal temperature 101°.2.

8 P. M.—Dog given as much cooked beef as he would eat.

8:30 P. M.—Thirty minims of putrid blood injected into the jugular vein.

June 8. 10 A. M.—Rectal temperature 101°.5. Thirty minims of putrid blood injected into the jugular vein.

3 P. M.—Rectal temperature 103°. Fifty minims of putrid blood injected as before.

4 P. M.—Rectal temperature 103°.8.

4:35 P. M.—Rectal temperature 103°.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
5:48 P. M.	.....	.....	67°.676	373
5:50	66°.68	70°.88		
6:10	68.36	70.76		
6:30	69.53	70.52		
6:50	70.16	70.52		
7:10	70.04	70.88		
7:30	70.16	70.97		
7:50	70.43	71.23		
8:10	70.43	71.42		
8:30	70.52	72.2		
8:50	70.88	72.32		
9:10	70.97	72.95		
9:30	70.97	72.95		
9:50	70.88	73.45		
10:10	70.88	72.41		
10:30	71.06	72.5		
10:48	.....	.....	72.42	749.2
	70.13 (mean)	71.73	4.744 (gain)	376.2
		70.13		
		1.6 (gain)		

10:50 P. M.—Rectal temperature 101°.8.

10:55 P. M.—Dog refuses to eat; some purging; injected thirty minims of putrid blood into peritoneal cavity.

June 9. 11:55 P. M.—Rectal temperature 102°.2.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:4 A.M.	.....	.....	70°.43	755.25
12:10	70°.52	71°.72		
12:30	71.42	71.72		
12:50	71.51	71.96		
1:10	71.33	72.08		
1:30	71.06	72.08		
1:50	70.88	72.32		
2:10	70.88	72.32		
2:30	70.25	72.2		
2:50	69.8	72.95		
3:10	69.08	73.04		
3:30	68.59	73.45		
3:50	68.54	73.45		
4:10	68.54	73.35		
4:30	68.24	73.14		
4:50	67.28	73.65		
5:10	67.76	73.35		
5:30	67.46	72.32		
5:50	68.45	72.5		
6:4	.....	.....	75.02	1196.94
	69.53 (mean)	72.64	4.59 (gain)	441.69
		69.53		
		3.11 (gain)		

6:25 A. M.—Rectal temperature 102°.4. Refuses to eat.

7:35 A. M.—Rectal temperature 102°.2.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
7:48 A.M.	.....	.....	71°.42	223.8
8	64°.88	69°.85		
8:20	67.04	69.54		
8:40	66.38	70.25		
9	66.2	71.51		
9:20	66.29	71.15		
9:40	66.38	70.64		
10	66.2	70.52		
10:20	66.29	71.96		
10:40	66.2	70.64		
11	66.29	70.97		
11:20	66.56	72.68		
11:40	67.46	71.33		
12:18 P. M.	67.16	71.33	73.52	558.1
	66.41 (mean)	70.95	2.1 (gain)	334.3
		66.41		
		4.54 (gain)		

12:18 P. M.—Rectal temperature 102°.4.

3 P. M.—Rectal temperature 102°.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:50 P. M.	.....	.....	69°.62	636
4:5	68°.72	71°.15		
4:20	70.16	70.06		
4:50	71.87	71.24		
5:10	72.33	71.72		
5:30	71.87	71.96		
5:50	71.78	71.96	70.88	776.4
	71.12 (mean)	71.35	1.26 (gain)	140.4
		71.12		
		0.23 (gain)		

5:50 P. M.—Rectal temperature 102°.8.
Dog died June 11.

Heat Dissipation.

First Period—

Quantity of air (V′) = 555.504 at 74°.46 — 32° = 42.46 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{555.504}{1.086} = 511$. $W = V \times 0.08073 = 41.25$

Rise in temp. of air 1.73 = t. $Q = W \times t \times$ sp. h. $= 41.25 \times 1.73 \times 0.2374 = 16.941$ = heat given to air.

Rise in temp. of water $4.11 \times 130.8589 = 537.83$ = heat given to calorimeter.

16.94 = heat given to air.

554.77 = heat dissipated in 6 hours.

Hourly dissipation of heat 92.461

Second Period—

Quantity of air (V′) = 471.1 at 75°.17 — 32° = 43.17 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{471.1}{1.088} = 433$. $W = V \times 0.08073 = 34.96$.

Rise in temp. of air 2.03 = t. $Q = W \times t \times$ sp. h. $= 34.96 \times 2.03 \times 0.2374 = 16.848$ = heat given to air.

Rise in temp. of water $3.07 \times 130.8589 = 401.7368$ = heat given to calorimeter.

16.848 = heat given to air.

418.5848 = heat dissipated in 5 hours.

Hourly dissipation of heat 83.7169

Third Period—

Quantity of air (V′) = 598.97 at 76°.11 — 32° = 44.11 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{598.97}{1.09} = 549.5$. $W = V \times 0.08073 = 44.361$

Rise in temp. of air 4.81 = t. $Q = W \times t \times$ sp. h. $= 44.361 \times 4.81 \times 0.2374 = 50.656$ = heat given to air.

Rise in temp. of water $3.06 \times 130.8589 = 400.4282$ = heat given to calorimeter.

50.656 = heat given to air.

451.0842 = heat dissipated in 6 hours.

Hourly dissipation of heat 75.1807

Fourth Period—

Quantity of air (V′) = 274.94 at 74°.48 — 32° = 42.48 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{274.94}{1.086} = 253.1$. $W = V \times 0.08073 = 20.43$

Rise in temp. of air 2.09 = t. $Q = W \times t \times$ sp. h. $= 20.43 \times 2.09 \times 0.2374 = 10.137$ = heat given to air.

Rise in temp. of water $1.809 \times 130.8589 = 236.7237$ = heat given to calorimeter.

10.137 = heat given to air.

246.8607 = heat dissipated in 3 hours.

Hourly dissipation of heat 82.2869

Fifth Period—

Quantity of air (V′) = 320.17 at 68°.92 — 32° = 36.92 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{320.17}{1.075} = 297.8$. $W = V \times 0.08073 = 24$

Rise in temp. of air 5.9 = t. $Q = W \times t \times$ sp. h. $= 24 \times 5.9 \times 0.2374 = 33.6158$ = heat given to air.

Rise in temp. of water $1.11 \times 130.8589 = 145.2534$ = heat given to calorimeter.

33.6158 = heat given to air.

178.8692 = heat dissipated in $3\frac{1}{2}$ hours.

Hourly dissipation of heat 51.055

Sixth Period—

Quantity of air (V′) = 498.7 at 66°.11 — 32° = 34.11 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{498.7}{1.069} = 466.5$. $W = V \times 0.08073 = 37.66$

Rise in temp. of air 8.02 = t. Q = W × t × sp. h. = 37.66 × 8.02 × 0.2374 = 71.7027 = heat given to air.
Rise in temp. of water 1.86 × 130.8589 = 243.3975 = heat given to calorimeter.
71.7027 = heat given to air.
315.1002 = heat dissipated in 6 hours.
Hourly dissipation of heat 52.5167

Seventh Period—

Quantity of air (V′) = 514.18 at 67°.73 — 32° = 35.73 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{514.18}{1.073} = 479.2$. $W = V \times 0.08073 = 38.686$

Rise in temp. of air 5.32 = t. Q = W × t × sp. h. = 38.686 × 5.32 × 0.2374 = 48.859 = heat given to air.
Rise in temp. of water 2.277 × 130.8589 = 297.9657 = heat given to calorimeter.
48.859 = heat given to air.
346.8247 = heat dissipated in 5½ hours.
Hourly dissipation of heat 63.0588

Eighth Period—

Quantity of air (V′) = 327.75 at 70°.58 — 32° = 38.58 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{327.75}{1.078} = 304$. $W = V \times 0.08073 = 24.54$

Rise in temp. of air 2.15 = t. Q = W × t × sp. h. = 24.54 × 2.15 × 0.2374 = 12.5255 = heat given to air.
Rise in temp. of water 2.124 × 130.8589 = 277.9443 = heat given to calorimeter.
12.5255 = heat given to air.
290.4698 = heat dissipated in 4 hours.
Hourly dissipation of heat 72.6174

Ninth Period—

Quantity of air (V′) = 376.2 at 71°.73 — 32° = 39.73 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{376.2}{1.08} = 348.3$. $W = V \times 0.08073 = 28.12$

Rise in temp. of air 1.6 = t. Q = W × t × sp. h. = 28.12 × 1.6 × 0.2374 = 10.6811 = heat given to air.
Rise in temp. of water 4.744 × 130.8589 = 620.7946 = heat given to calorimeter.
10.6811 = heat given to air.
631.4757 = heat dissipated in 5 hours.
Hourly dissipation of heat 126.2951

Tenth Period—

Quantity of air (V′) = 441.69 at 72°.64 — 32° = 40.64 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{441.69}{1.08} = 408.9$. $W = V \times 0.08073 = 33.01$

Rise in temp. of air 3.11 = t. Q = W × t × sp. h. = 33.01 × 3.11 × 0.2374 = 24.3717 = heat given to air.
Rise in temp. of water 4.59 × 130.8589 = 600.6423 = heat given to calorimeter.
24.3717 = heat given to air.
625.014 = heat dissipated in 6 hours.
Hourly dissipation of heat 104.17

Eleventh Period—

Quantity of air (V′) = 334.3 at 70°.95 — 32° = 38.95 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{334.3}{1.079} = 309.8$. $W = V \times 0.08073 = 25.01$

Rise in temp. of air 4.54 = t. Q = W × t × sp. h. = 25.01 × 4.54 × 0.2374 = 26.9557 = heat given to air.
Rise in temp. of water 2.1 × 130.8589 = 274.8038 = heat given to calorimeter.
26.9557 = heat given to air.
301.7595 = heat dissipated in 4½ hours.
Hourly dissipation of heat 67.058

Twelfth Period—

Quantity of air (V′) = 140.4 at 71°.35 — 32° = 39.35 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{140.4}{1.08} = 130$. $W = V \times 0.08073 = 10.495$

Rise in temp. of air 0.23 = t. $Q = W \times t \times$ sp. h. $= 10.495 \times 0.23 \times 0.2374 = 0.5733$ = heat given to air.

Rise in temp. of water 1.26 × 130.8589 = 164.8822 = heat given to calorimeter.
0.5733 = heat given to air.

165.4555 = heat dissipated in 2 hours.

Hourly dissipation of heat 82.7277

Heat Production.

First Period—

Rise of bodily temperature in 6 hours 1°, in 1 hour 0.1666 = t.

$Q = W \times t \times$ sp. h. $= 25 \times 0.167 \times 0.75 = 3.13125$ = heat added to reserve.
92.461 = hourly dissipation of heat.
3.13125 = hourly addition to heat reserve.

Hourly production of heat 95.59225

Second Period—

Fall of bodily temperature in $5\frac{2}{3}$ hours 0°.2, in 1 hour 0.0353 = t.

$Q = W \times t \times$ sp. h. $= 25 \times 0.0353 \times 0.75 = 0.6619$ = heat taken from reserve.
83.7169 = hourly dissipation of heat.
0.6619 = hourly loss from heat reserve.

Hourly production of heat 83.055

Third Period—

Fall of bodily temperature in $6\frac{5}{8}$ hours 0°.8, in 1 hour 0.11707 = t.

$Q = W \times t \times$ sp. h. $= 25 \times 0.11707 \times 0.75 = 2.1951$ = heat taken from reserve.
75.1807 = hourly dissipation of heat.
2.1951 = hourly loss from heat reserve.

Hourly production of heat 72.9856

Fourth Period—

Rise of bodily temperature in $3\frac{1}{2}$ hours 0°.7, in 1 hour 0.2 = t.

$Q = W \times t \times$ sp. h. $= 25 \times 0.2 \times 0.75 = 3.75$ = heat added to reserve.
82.2869 = hourly dissipation of heat.
3.75 = hourly addition to heat reserve.

Hourly production of heat 86.0369

Fifth Period—

Rise of bodily temperature in 4 hours 0°.5, in 1 hour 0.125 = t.

$Q = W \times t \times$ sp. h. $= 25 \times 0.125 \times 0.75 = 2.6812$ = heat added to reserve.
51.1055 = hourly dissipation of heat.
2.34375 = hourly addition to heat reserve.

Hourly production of heat 53.4494

Sixth Period—

No change in bodily temperature.

Hourly dissipation of heat = *hourly production of heat* 52.5167

Seventh Period—

Fall of bodily temperature in 5 hours 0°.4, in 1 hour 0.067 = t.

$Q = W \times t \times$ sp. h. $= 25 \times 0.067 \times 0.75 = 1.267$ = heat taken from reserve.
63.0588 = hourly dissipation of heat.
1.26 = hourly loss from heat reserve.

Hourly production of heat 61.7988

Eighth Period—

Rise of bodily temperature in 4 hours 0°.6, in 1 hour 0.15 = t.
Q = W × t × sp. h. = 25 × 0.15 × 0.75 = 2.8125 = heat taken from reserve.

72.6174 = hourly dissipation of heat.
2.8125 = hourly addition to heat reserve.

Hourly production of heat 75.4299

Ninth Period—

Fall of bodily temperature in $6\frac{1}{3}$ hours 1°.8, in 1 hour 0.28421 = t.
Q = W × t × sp. h. = 25 × 0.28421 × 0.75 = 5.325 = heat taken from reserve.

126.2951 = hourly dissipation of heat.
5.325 = hourly loss from heat reserve.

Hourly production of heat 120.9701

Tenth Period—

Rise of bodily temperature in $6\frac{1}{2}$ hours 0°.6, in one hour 0.0923 = t.
Q = W × t × sp. h. = 25 × 0.0923 × 0.75 = 1.7306 = heat added to reserve.

104.17 = hourly dissipation of heat.
1.7306 = hourly addition to heat reserve.

Hourly production of heat 105.9006

Eleventh Period—

Rise of bodily temperature in $5\frac{2}{3}$ hours 0°.2, in 1 hour 0.035 = t.
Q = W × t × sp. h. = 25 × 0.035 × 0.75 = 0.6563 = heat added to reserve.

67.058 = hourly dissipation of heat.
0.6563 = hourly addition to heat reserve.

Hourly production of heat 67.7143

Twelfth Period—

Rise of bodily temperature in $2\frac{5}{6}$ hours 0°.2, in 1 hour 0.071 = t.
Q = W × t × sp. h. = 25 × 0.071 × 0.75 = 1.331 = heat added to reserve.

82.7277 = hourly dissipation of heat.
1.331 = hourly addition to heat reserve.

Hourly production of heat 84.0587

RECAPITULATON.

June 4. Dog had eaten at 8 A. M. ¾ lb. of cooked liver.

Day.	Time.	Hourly Heat Dissipation.	Hourly Heat Production.	Rect. Temp. (Fah.)	Remarks.
First day. June 4, 11:50 A. M. to June 5, 11:50 A. M.	11:53 A. M. to 5:53 P. M.	92.461	95.59225	102°.6 to 103.6	At 6:15 P. M. ate 10 oz. of cooked mutton.
	6:47 P. M. to 11:47 P. M.	83.7169	83.055	102.4 to 102.2	
	12:45 A. M. to 6:45 A. M.	75.1807	72.9856	102.2 to 101.4	
	8:48 A. M. to 11:48 A. M.	82.2869	86.0369	101.2 to 101.9	8 A. M. ate 3 oz. of cooked mutton.
Has had no food since 8 A. M., and none during following 24 hours.					
Second day June 5, 8 P. M. to June 6, 8 P. M.	8:15 P. M. to 11:45 P. M.	51.055	53.4494	101.3 to 101.8	
	12:47 A. M. to 6:47 A. M.	52.5167	52.5167	101.8	
	9:20 A. M. to 2:20 P. M.	63.0588	61.7983	101.4 to 101	
	3:37 P. M. to 7:37 P. M.	72.6174	75.4299	100.6 to 101.2	

Dog at 8 P. M. given as much beef as he would eat. At 8:30 P. M. 30 minims of putrid blood injected into jugular.
June 8, 10:15 A. M. 30 minims of putrid blood injected.
10:50 P. M. dog refuses to eat; some purging. 11 P. M. injected 30 minims of putrid blood into peritoneal cavity.

Third day. June 8, 6 P. M. to June 9, 6 P. M.	5:48 P. M. to 10:48 P. M.	126.2951	120.9701	103.6 to 101.8	
	12:4 A. M. to 6:4 A. M.	104.17	105.49375	101.8 to 102.4	
	7:48 A. M. to 12:18 P. M.	67.058	67.7143	102.2 to 102.4	Refuses to eat.
	3:50 P. M. to 5:50 P. M.	82.7277	84.0587	102.6 to 102.8	

Died June 11, A. M.

SUMMARY.

	Time in Calorimeter.	Average Hourly Heat Dissipation.	Average Hourly Heat Production.	Extremes of Rect. Temp. (Fah.)	Average Rect. Temp.
First day.	20 hours.	83.5648	84.2426	101°.4 to 103.6	102°.24
Second day.	18 hours.	59.4355	60.1560	100.6 to 101.8	101.405
Third day.	17½ hours.	98.4978	97.7511	101.8 to 103.6	102.4

Experiment 115.

A rabbit. Weight 3.5 pounds.

June 4. 12:35 P. M.—Rectal temperature 103°.6.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:35 P. M.	69°.17	71°.42	69°.92	1026.7
12:45	68.99	71.96		
1	70.04	72.08		
1:15	70.64	72.59		
1:30	71.75	72.86		
1:45	71.51	73.25		
2	72.08	73.76		
2:15	72.42	73.25		
2:30	72.42	73.35		
2:45	72.73	74.57		
3	72.89	75.2		
3:15	72.99	75.2		
3:30	73.4	75.48		
3:45	73.85	75.68		
4	73.94	76.16		
4:15	73.94	76.37		
4:30	74.48	76.55		
4:45	74.93	76.91		
5	75.02	77		
5:15	75.02	77		
5:30	75.65	76.82		
5:45	75.38	77.27		
6:5	.....	.....	71.69	1166.2
	72.85 (mean)	74.76	1.77 (gain)	139.5
		72.85		
		1.91 (gain)		

6:5 P. M.—Rectal temperature 103°.6. Rabbit had skin badly rubbed off in taking him out of the calorimeter.

6:45 P. M.—Rectal temperature 103°.6.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
7:2 P. M.	71°.96	76°.46	72°.116	166.1
7:15	73.1	76.91		
7:35	74.12	76.37		
7:55	73.85	75.8		
8:15	73.52	75.38		
8:38	73.4	75.2		
8:55	73.3	74.74		
9:15	73.3	74.66		
9:35	73.1	74.84		
9:55	73.09	74.66		
10:15	73.19	74.75		
10:35	73.19	74.66		
10:55	72.53	74.75		
11:15	72.42	74.39		
11:35	73.09	74.39		
12:2 A. M.	.....	.....	73.64	296.5
	73.14 (mean)	75.2	1.524 (gain)	130.4
		73.14		
		2.06 (gain)		

12:20 A. M.—Rectal temperature 104°.6.

June 5.

1 A. M.—Rectal temperature 103°.8.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
1:12 A. M.	.....	.....	72°.2	299
1:30	.....	.....		
1:35	70°.97	76°.46		
1:55	71.78	75.92		
2:15	72.32	75.2		
2:35	72.08	74.84		
2:55	71.42	74.66		
3:15	71.78	74.48		
3:35	71.87	74.48		
3:55	71.6	74.3		
4:15	71.33	73.88		
4:35	70.88	73.66		
4:55	70.43	73.45		
5:15	70.64	73.14		
5:35	70.88	73.14		
5:55	70.97	73.04		
6:12	.....	.....	73.46	396.64
	71.35 (mean)	74.33 71.35	1.26 (gain)	97.64
		2.98 (gain)		

6:20 A. M.—Rectal temperature 105°.8.

9 A. M.—Rectal temperature 105°.4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
9 A.M.	.....	.....	69°.32	397.5
9:30	71°.33	73°.45		
9:50	72.08	73.45		
10:10	72.32	73.45		
10:30	72.52	73.55		
10:50	72.73	73.76		
11:10	72.83	73.76		
11:30	72.89	73.88		
12	.....	.....	70.34	483.4
	72.4 (mean)	73.61 72.4	1.02 (gain)	85.9
		1.21 (gain)		

12 noon.—Rectal temperature 105°.4.

Heat Dissipation.

First Period—

Quantity of air (V′) = 139.5 at 74°.76 — 32° = 42.76 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{139.5}{1.087} = 128.3$. $W = V \times 0.08073 = 10.36$

Rise in temp. of air 1.91 = t. $Q = W \times t \times$ sp. h. $= 10.36 \times 1.91 \times 0.2374 = 4.6976$ = heat given to air.

Rise in temp. of water $1.77 \times 79.544 = 140.7928$ = heat given to calorimeter.

4.6976 = heat given to air.

145.4904 = heat dissipated in $5\frac{1}{2}$ hours.

Hourly dissipation of heat 26.4527

Second Period—

Quantity of air (V′) = 130.4 at 75°.2 — 32° = 43.2 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{130.4}{1.088} = 119.8$. $W = V \times 0.08073 = 9.67$

Rise in temp. of air 2.06 = t. $Q = W \times t \times$ sp. h. $= 9.67 \times 2.06 \times 0.2374 = 4.729$ = heat given to air.

Rise in temp. of water $1.524 \times 79.544 = 121.225$ = heat given to calorimeter.
4.729 = heat given to air.
125.954 = heat dissipated in 5 hours.
Hourly dissipation of heat 25.1908

Third Period—

Quantity of air (V′) = 97.64 at 74°.33 — 32° = 42.33 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{97.64}{1.086} = 90$. $W = V \times 0.08073 = 7.266$

Rise in temp. of air 2.98 = t. $Q = W \times t \times$ sp. h. $= 7.266 \times 2.98 \times 0.2374 = 5.1397$ = heat given to air.
Rise in temp. of water $1.26 \times 79.544 = 100.2254$ = heat given to calorimeter.
5.1397 = heat given to air.
105.3651 = heat dissipated in 5 hours.
Hourly dissipation of heat 21.073

Fourth Period—

Quantity of air (V′) = 85.9 at 73°.61 — 32° = 41.61 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{85.9}{1.085} = 79.2$. $W = V \times 0.08073 = 6.39$

Rise in temp. of air 1.21 = t. $Q = W \times t \times$ sp. h. $= 6.39 \times 1.21 \times 0.2374 = 1.8355$ = heat given to air.
Rise in temp. of water $1.02 \times 79.544 = 81.1349$ = heat given to calorimeter.
1.8355 = heat given to air.
82.9704 = heat dissipated in 3 hours.
Hourly dissipation of heat 27.6568

Heat Production.

First Period—

No change in bodily temperature.
Hourly dissipation of heat = *hourly production of heat* 26.4527

Second Period—

Rise of bodily temperature in $5\frac{1}{2}$ hours 1°, in 1 hour 0.182 = t.
$Q = W \times t \times$ sp. h. $= 3.5 \times 0.182 \times 0.75 = 0.4777$ = heat added to reserve.
25.1908 = hourly dissipation of heat.
0.4777 = hourly addition to heat reserve.
Hourly production of heat 25.6685

Third Period—

Rise of bodily temperature in $5\frac{1}{3}$ hours 2°, in 1 hour 0.375 = t.
$Q = W \times t \times$ sp. h. $= 3.5 \times 0.375 \times 0.75 = 0.9844$ = heat added to reserve.
21.073 = hourly dissipation of heat.
0.9844 = hourly addition to heat reserve.
Hourly production of heat 22.0574

Fourth Period—

No change in bodily temperature.
Hourly dissipation of heat = *hourly production of heat* 27.6568

RECAPITULATION.

	Time.	Heat Dissipation.	Heat Production.	Aver. Rect. Temp. (Fah.)	Remarks.
First period.	12:35 P. M. to 6:5 P. M.	26.4527	26.4527	103°.6	
Second period.	7:2 P. M. to 12:2 A. M.	25.1908	25.6685	104.1	
Third period.	1:12 A. M. to 6:12 A. M.	21.073	22.0574	104.8	
Fourth period.	9 A. M. to 12 A. M.	27.6568	27.6568	105.4	

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Experiment 116.

A rabbit. Weight 4.1 pounds.

June 5. 8:30 P. M.—Rectal temperature 103°.6.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
8:40 P. M.	.....	.....	68°.12	475.65
9	65°.3	69°.35		
9:20	64.31	68.6		
9:40	63.68	68.24		
10	63.5	67.37		
10:20	62.87	66.8		
10:40	62.24	66.92		
11	62.14	66.56		
11:20	61.74	66.38		
11:40	61.14	65.72		
12:10 A. M.	.....	.....	68.81	580.75
	62.99 (mean)	67.33	0.69 (gain)	105.1
		62.99		
		4.34 (gain)		

June 6. 12:30 A. M.—Rectal temperature 103°.4.

12:50 A. M.—Rectal temperature 102°.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen Meter. (cub. ft.)
1:10 A. M.	.....	.....	67°.04	580.5
1:20	60°.1	67°.72		
1:40	59.4	65.84		
2	59.1	65.12		
2:20	59.3	65.72		
2:40	59.3	65.48		
3	58.1	65.39		
3:20	57.8	63.86		
3:40	58.9	64.94		
4	58.6	65.12		
4:20	57.1	63.77		
4:40	57.3	64.4		
5	57.1	63.77		
5:20	56.1	63.05		
5:40	56.9	63.23		
6	56.5	62.15		
6:20	57.8	62.36		
6:40	.....	.....	67.298	681
	58.1 (mean)	64.49	0.258 (gain)	100.5
		58.1		
		6.39 (gain)		

6:50 A. M.—Rectal temperature 101°.2.

9:10 A. M.—Rectal temperature 100°.8.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
9:20 A. M.	60°.6	63°.86	64°.283	708.2
9:40	59.8	63.95		
10	60	63.77		
10:20	59.9	63.86		
10:40	61.24	64.04		
11	62.24	64.31		
11:20	62.6	64.52		
11:40	62.72	64.85		
12 M.	62.96	64.94		
12:20 P. M.	63.23	65.21		
12:40	63.32	65.39		
1	63.5	65.6		
1:20	63.15	65.96		
1:40	64.13	66.29		
2	64.49	66.8		
2:20	64.76	67.01		
2:50	.....	.....	65.84	819.3
	62.41 (mean)	65.02	1.557 (gain)	111.1
		62 41		
		2.61 (gain)		

2:55 P. M.—Rectal temperature 101°.8.

3:50 P. M.—Rectal temperature 101°.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
4 P. M.	64°.76	68°.68	66°.08	853.5
4:20	68.45	69.89		
4:40	68.54	69.98		
5	68.54	69.89		
5:20	68.72	69.98		
5:40	68.99	70.08		
6	69.08	69.98		
6:20	68.90	69.98		
6:40	69.44	70.16		
7	68.81	70.07		
7:25	68.45	68.98		
8	.....	.....	66.92	969
	68.43 (mean)	69.79	0.84 (gain)	115.5
		68.43		
		1.36 (gain)		

8:10 P. M.—Rectal temperature 101°.6.

June 7. 11 A. M.—Ten minims of putrid blood injected into the jugular vein.

June 8. 10:30 A. M.—Five minims of putrid blood injected into the jugular vein.

2:40 P. M.—Five minims of putrid blood injected into the jugular vein.

June 8. 4:10 P. M.—Rectal temperature 105°.4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
4:31 P. M.	.....	.....	65°.642	960.3
5:15	.....	70°.88		
5:50	66°.68	70.6		
6:10	68.36	74.24		
6:30	69.53	70.48		
6:50	70.16	71.6		
7:10	70.04	71.69		
7:30	70.16	71.87		
7:50	70.43	72.05		
8:10	70.43	71.87		
8:30	70.52	71.96		
8:50	70.88	72.14		
9:10	70.97	72.23		
9:30	70.97	72.23		
9:50	70.88	72.32		
10:10	70.88	72.23		
10:31	71.06	72.32	67.88	1126.13
	70.13 (mean)	71.92	2.238 (gain)	165.83
		70.13		
		1.79 (gain)		

10:40 P. M.—Rectal temperature 104°.5.

11:20 P. M.—Injected 10 minims of putrid blood into the peritoneal cavity. Rectal temperature 104°.6.

June 8 and 9.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:27 P. M.	.....	.....	68°.36	125.75
12:10 A. M.	70°.52	73°.88		
12:30	71.42	71.6		
12:50	71.51	73.49		
1:10	71.33	73.49		
1:30	71.06	72.8		
1:50	70.88	73.22		
2:10	70.88	73.22		
2:30	78.25	73.04		
2:50	69.8	72.8		
3:10	69	72.41		
3:30	68.54	71.87		
3:50	68.54	71.87		
4:10	68.54	71.6		
4:30	68.24	71.36		
4:50	67.28	71.12		
5:10	67.76	70.79		
5:27	.....	.....	70.04	295.47
	69.73 (mean)	72.41	1.68 (gain)	169.72
		69.73		
		2.68 (gain)		

5:35 A. M.—Rectal temperature 103°.8.

Rabbit refuses entirely to eat; stays permanently in one position and seems very sick.

June 9. 6:50 A. M.—Some slimy rectal discharge. Rectal temperature 103°.2.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
7:11 A. M.	.....	.....	69°.272	297.5
7:30	67°.36	69°.8		
7:45	67.36	69.68		
8	64.88	69.44		
8:20	66.38	69.2		
8:40	66.2	69.08		
9	66.29	68.9		
9:20	66.38	68.72		
9:40	66.2	68.6		
10	67.04	68.36		
10:20	66.29	68.36		
10:40	66.2	68.27		
11	66.29	68.18		
11:20	66.56	68.18		
11:40	67.46	68.36		
12:11 P. M.	67.16	68.18	70.04	431.95
	66.54 (mean)	68.75	0.768 (gain)	134.45
		66.54		
		2.21 (gain)		

12:20 P. M.—Rectal temperature 105° 8.

1:10 P. M.—Rectal temperature 102°.2.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:17 P. M.	.....	.....	69°.14	445
1:40	64°.49	68°.72		
2	68.54	68.9		
2:20	68.90	69.2		
2:40	68.63	69.44		
3	69.53	69.68		
3:17	.....	.....	69.44	504
	68.02 (mean)	69.19	0.3 (gain)	59
		68.02		
		1.17 (gain)		

3:25 P. M.—Rectal temperature 103°.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
4:5 P. M.	68°.72	71°.6	69°.32	507.8
4:20	70.16	71.69		
4:50	71.87	71.87		
5:10	72.33	72.41		
5:30	71.87	72.41		
5:50	71.78	72.41		
6:5	.....	.....	69.71	553.2
	71.12 (mean)	72.06	0.39 (gain)	45.4
		71.12		
		0.94 (gain)		

6:10 P. M.—Rectal temperature 103°.3.

June 10. Rabbit died.

Heat Dissipation.

First Period—

Quantity of air (V′) = 105.1 at 67°.33 — 32° = 35.33 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{105.1}{1.072} = 98.04$. $W = V \times 0.08073 = 7.91$

Rise in temp. of air 4.34 = t. $Q = W \times t \times$ sp. h. = $7.91 \times 4.34 \times 0.2374 = 8.1498$ = heat given to air.
Rise in temp. of water $0.69 \times 79.544 = 54.88536$ = heat given to calorimeter.
8.1498 = heat given to air.

63.03516 = dissipation of heat in 3½ hours.

Hourly dissipation of heat 18.01

Second Period—

Quantity of air (V′) = 100.5 at 64°.49 — 32° = 32.49 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{100.5}{1.066} = 94.3$. $W = V \times 0.08073 = 7.61$

Rise in temp. of air 6.39 = t. $Q = W \times t \times$ sp. h. = $7.61 \times 6.39 \times 0.2374 = 11.545$ = heat given to air.
Rise in temp. of water $0.258 \times 79.544 = 20.5223$ = heat given to calorimeter.
11.545 = heat given to air.

32.0673 = heat dissipated in 5½ hours.

Hourly dissipation of heat 5.8304

Third Period—

Quantity of air (V′) = 111.1 at 65°.02 — 32° = 33.02 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{111.1}{1.067} = 10.41$. $W = V \times 0.08073 = 0.84$

Rise in temp. of air 2.61 = t. $Q = W \times t \times$ sp. h. = $2.61 \times 0.84 \times 0.2374 = 0.5205$ = heat given to air.
Rise in temp. of water $1.557 \times 79.544 = 123.85$ = heat given to calorimeter.
0.5205 = heat given to air.

124.3705 = heat dissipated in 5½ hours.

Hourly dissipation of heat 22.6128

Fourth Period—

Quantity of air (V′) = 115.5 at 69°.79 — 32° = 37.79 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{115.5}{1.077} = 107.2$. $W = V \times 0.08073 = 8.654$

Rise in temp. of air 1.36 = t. $Q = W \times t \times$ sp. h. = $8.65 \times 1.36 \times 0.2374 = 2.793$ = heat given to air.
Rise in temp. of water $0.84 \times 79.544 = 66.81696$ = heat given to calorimeter.
2.793 = heat given to air

69.60996 = heat dissipated in 4 hours.

Hourly dissipation of heat 17.4025

Fifth Period—

Quantity of air (V′) = 165.83 at 71°.92 — 32° = 39.92 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{165.83}{1.08} = 153.5$. $W = V \times 0.08073 = 12.4$

Rise in temp. of air 1.79 = t. $Q = W \times t \times$ sp. h. = $12.4 \times 1.79 \times 0.2374 = 5.27$ = heat given to air.
Rise in temp. of water $2.238 \times 79.544 = 178.019472$ = heat given to calorimeter.
5.27 = heat given to air.

183.289472 = heat dissipated in 6 hours.

Hourly dissipation of heat 30.5482

Sixth Period—

Quantity of air (V′) = 169.72 at 72°.41 — 32° = 40.41 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{169.72}{1.08} = 157.1$. $W = V \times 0.08073 = 12.68$

Rise in temp. of air 2.68 = t. $Q = W \times t \times$ sp. h. $= 12.68 \times 2.68 \times 0.2374 = 8.067$ = heat given to air.

Rise in temp. of water $1.68 \times 79.544 = 133.6339$ = heat given to calorimeter.

8.067 = heat given to air.

141.7009 = heat dissipated in 6 hours.

Hourly dissipation of heat 23.6168

Seventh Period—

Quantity of air (V′) = 134.45 at 68°.75 — 32° = 36.75 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{134.45}{1.075} = 125.07$. $W = V \times 0.08073 = 10.09$

Rise in temp. of air 2.21 = t. $Q = W \times t \times$ sp. h. $= 10.09 \times 2.21 \times 0.2374 = 5.294$ = heat given to air.

Rise in temp. of water $0.768 \times 79.544 = 61.089792$ = heat given to calorimeter.

5.294 = heat given to air.

66.383792 = heat dissipated in 5 hours.

Hourly dissipation of heat 13.2767

Eighth Period—

Quantity of air (V′) = 59 at 69°.19 — 32° = 37.19 = t′.

$V + (V \times t' \times 0.002035) = V$. $V = \frac{59}{1.076} = 54.8$. $W = V \times 0.08073 = 4.4$

Rise in temp. of air 1.17 = t. $Q = W \times t \times$ sp. h. $= 4.4 \times 1.17 \times 0.2374 = 1.2221$ = heat given to air.

Rise in temp. of water $0.3 \times 79.544 = 23.8632$ = heat given to calorimeter.

1.2221 = heat given to air.

25.0853 = heat dissipated in 2 hours.

Hourly dissipation of heat 12.5426

Ninth Period—

Quantity of air (V′) = 45.4 at 72°.06 — 32° = 40.06 = t′.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{45.4}{1.08} = 42.04$. $W = V \times 0.08073 = 3.394$

Rise in temp. of air 0.94 = t. $Q = W \times t \times$ sp. h. $= 3.4 \times 0.94 \times 0.2374 = 0.7587$ = heat given to air.

Rise in temp. of water $0.39 \times 79.544 = 31.02216$ = heat given to calorimeter.

0.7587 = heat given to air.

31.78086 = dissipation of heat in 2 hours.

Hourly dissipation of heat 15.89043

Heat Production.

First Period—

Fall of bodily temperature in 4 hours 0°.2, in 1 hour 0.5 = t.

$Q = W \times t \times$ sp. h. $= 4.1 \times 0.5 \times 0.75 = 0.1537$ = heat taken from reserve.

18.01 = hourly dissipation of heat.

0.1537 = hourly loss from heat reserve.

Hourly production of heat 17.8563

Second Period—

Fall of bodily temperature in 6 hours 0°.8, in 1 hour 0.1333 = t.

$Q = W \times t \times$ sp. h. $= 4.1 \times 0.1333 \times 0.75 = 0.4099$ = heat taken from reserve.

5.8304 = hourly dissipation of heat.

0.4099 = hour' loss from heat reserve.

Hourly production of heat 5.4205

Third Period—

Rise of bodily temperature in $5\frac{3}{4}$ hours 1°, in 1 hour 0.17 = t.
Q = W × t × sp. h. = 4.1 × 0.17 × 0.75 = 0.5219 = heat added to reserve.

22.6128 = hourly dissipation of heat.
0.5219 = hourly addition to heat reserve.

Hourly production of heat 23.1347

Fourth Period—

No change of bodily temperature.
Heat dissipated hourly = *hourly production of heat* 17.4025

Fifth Period—

Fall of bodily temperature in $6\frac{1}{2}$ hours 0°.9, in 1 hour 0.1384 = t.
Q = W × t × sp. h. = 4.1 × 0.1384 × 0.75 = 0.4256 = heat taken from reserve.

30.5482 = hourly dissipation of heat.
0.4256 = hourly loss from heat reserve.

Hourly production of heat 30.1226

Sixth Period—

Fall of bodily temperature in $6\frac{1}{4}$ hours 0°.8, in 1 hour 0.128 = t.
Q = W × t × sp. h. = 4.1 × 0.128 × 0.75 = 0.3937 = heat taken from reserve.

23.6168 = hourly dissipation of heat.
0.3937 = hourly loss from heat reserve.

Hourly production of heat 23.3231

Seventh Period—

Rise of bodily temperature in $5\frac{1}{2}$ hours 2°.6, in 1 hour 0.4727 = t.
Q = W × t × sp. h. = 4.1 × 0.4727 × 0.75 = 1.4535 = heat added to reserve.

13.2767 = hourly dissipation of heat.
1.4535 = hourly addition to reserve.

Hourly production of heat 14.7302

Eighth Period—

Rise of bodily temperature in $2\frac{1}{4}$ hours 1°.4, in 1 hour 0.622 = t.
Q = W × t × sp. h. = 4.1 × 0.622 × 0.75 = 1.9126 = heat added to reserve.

12.5426 = hourly dissipation of heat.
1.9126 = hourly addition to heat reserve.

Hourly production of heat 14.4552

Ninth Period—

Fall of bodily temperature in $2\frac{3}{4}$ hours 0°.3, in 1 hour 0.11 = t.
Q = W × t × sp. h. = 4.1 × 0.11 × 0.75 = 0.3382 = heat taken from reserve.

15.8904 = hourly dissipation of heat.
0.3382 = heat taken from reserve.

Hourly production of heat 15.5522

RECAPITULATION.

	Time.	Heat Dissipation.	Heat Production.	Rect. Temp. (Fah.)	Remarks.
First day. June 5, 8:30 P. M. to June 6, 8:30 P. M.	8:40 P. M. to 12:10 A. M.	18.01	17.8563	103°.6 to 103°.4	
	1:10 A. M. to 6:40 A. M.	5.8304*	5.4205*	102 to 101.2	
	9:20 A. M. to 2:50 P. M.	22.6128	23.1347	100.8 to 101.8	
	4 P. M. to 8 P. M.	17.4025	17.4025	101.6 to 101.6	
Second day. June 9, 4 P. M. to June 10, 4 P. M.	4:31 P. M. to 10:31 P. M.	30.5482	30.1226	105.4 to 104.5	11.20 P. M.—Ten minims of putrid blood injected into the peritoneal cavity.
	11:27 P. M. to 5:27 A. M.	23.6168	23.3231	104.6 to 103.8	
	7:11 A. M. to 12:11 P. M.	13.2767	14.7302	103.2 to 105.8	
	1:17 P. M. to 3:17 P. M.	12.5426	14.4552	102.2 to 103.6	

June 7. 11 A. M.—Ten minims of putrid blood injected into the jugular vein.
June 8. 10.30 A. M.—Five minims of putrid blood injected into the jugular vein.
2:40 P. M.—Five minims of putrid blood injected into the jugular vein.

SUMMARY.

	Time in Calorimeter.	Average Hourly Heat Dissipation.	Average Hourly Heat Production.	Extremes of Rect. Temp. (Fah.)	Average Rect. Temp. (Fah.)
First day.	13 hours.	.....	19.4955	100°.8 to 103°.6	101.6
Second day.	19 hours.	.....	22.2755	102.2 to 105.8	104.2

The experiments which have just been recorded, although undertaken for the purpose of determining whether there is or is not a greater production of heat in fever than in health, are capable of throwing light upon other problems, and it seems best to examine one or two of these before discussing the main question. There are two inquiries concerning the production of heat in health which may well here be studied. First, as to the existence or non-existence of a regular diurnal cycle of change in the heat production corresponding to the diurnal variations of bodily temperature. Second, as to the effect of food upon heat production. Of the experiments capable of throwing light upon the second of these inquiries No. 110 affords two days for comparison: the first of these days the dog ate one pound of raw liver when entering the calorimeter; the second he was without food. During the first day his average hourly heat production was 105.445; during the second day it was 61.4198 units; further, during the five hours immediately after the ingestion of the liver it was 176.8262, whilst during the second day the highest hourly production reached was 89.2437. The next experiment bearing directly upon the point now at issue is No. 114. During the first day the dog ate at intervals considerably over a pound and a half of meat, whilst on the second day he fasted; the result being that the average hourly heat production was the first day 84.2426, the second day 60.156 units. The decisive results obtained in these two experiments are confirmed by the immediate effects of the administration of food in one or two of the other experiments. They are also in accord with the results obtained by Senator, so that it may be considered demonstrated that the ingestion of a large amount of animal food is usually followed by an enormous increase in the pro-

* There was evidently some mistake made in reading the calorimetrical thermometer in this run, hence in making average it is omitted.

duction of heat. The conclusion thus reached taken in conjunction with the facts that heat still continues to be produced in starvation, and that various functional actions, as muscular movement and secretion in animals, and flowering in plants, have been found by various experimenters to be causes of local heat development, indicates that there are in the animal economy two distinct general sources of heat: first, the destruction, which probably occurs in the blood, of the excess of crude food material; second, nutritive changes in tissue, including all changes in the blood itself at the expense of its permanent constituents. It has not been proven, but it is most probable, that the heat centre, investigated in the previous chapter, affects solely the latter source of animal heat.

The effect of the ingestion of food upon heat production is so great and immediate that, if we desire to discover whether there is a diurnal cycle of alteration in the heat production, we must look at the records of those days when no food was taken, *i. e.*, when there was the greatest freedom from known disturbing causes. Ranging side by side the records of the four experiments at command for present purposes, and inverting the time as necessary to make the records coincide as nearly as possible, we obtain the following table. Each experiment consists of a connected twenty-four hours, although the periods of time did not always actually follow one another as arranged in the table.

Experiment 110.		Experiment 112.		Experiment 114.	
Time.	Heat Production.	Time.	Heat Production.	Time.	Heat Production.
6:16 P. M. to 11:16 P. M.	66.6627	5:11 P. M. to 10:11 P. M.	58.6187	8:15 P. M. to 11:45 P. M.	53.4494
12:10 A. M. to 5:10 A. M.	40.5944	11:3 P. M. to 4:3 A. M.	69.8756	12:47 A. M. to 6:47 A. M.	52.5167
6:23 A. M. to 11:23 A. M.	65.8729	5 A. M. to 10 A. M.	63.86	9:20 A. M. to 2:20 P. M.	61.7988
1:30 A. M. to 3:30 P. M.	89.2437	12:13 P. M. to 4:13 P. M.	84.159	3:37 P. M. to 7:37 P. M.	75.4299

When these experiments were performed the use to which they are at present being put was not thought of. The periods of calorimetrical observation do not therefore correspond closely. Nevertheless the general drift is sufficiently similar for comparison. If we tabulate the periods of maximum and minimum production they will stand as follows:—

Experiment.	Maximum Period.	Minimum Period.
110	1:30 P. M. to 3:30 P. M.	12:10 A. M. to 5:10 A. M.
112	12:13 P. M. to 4:13 P. M.	5:11 P. M. to 11:11 P. M.
114	3:37 P. M. to 7:37 P. M.	8:15 P. M. to 11:45 P. M.

On looking over this tabulated statement it will be seen that whilst there is some correspondence there is also a good deal of divergence. The time of maximum heat production in all is earlier or later in the afternoon; in two the time of minimum heat production is in the evening. This indicates that there is usually a tendency in normal dogs to an increase of heat production in the afternoon, and a diminution of it in the evening. The experiments are, however, not altogether concordant, and are too few to settle the question; but it is evident that if a tendency to a rhythmical production of animal heat does exist, such tendency must be entirely subservient to the accidents of feeding, exercise, etc., and that at least in the dog any diurnal cycle of bodily temperature which may exist must be de-

pendent upon the relations of heat dissipation to heat production rather than upon any dominant alteration of heat production. It is perhaps going too far to assume at present that what is true of the dog must also be true of the man, but the probabilities are that in this respect there is no difference between the two, for my experience seems to show that there is in dogs as well as man suffering from pyæmia an evening rise of temperature.

Coming now to the main question—the one for whose answering the present series of experiments were especially undertaken—I find the evidence of six of the experiments is best displayed by placing the results in tabular form as follows. The seventh experiment differs from the others in that it did not extend over several days, and its results therefore cannot be thrown into the same table with those of the others. The headings of the table explain sufficiently its purport without further comment.

	Food Day.			Hunger Day.			First Fever Day.			Second Fever Day.		
No. of Exp.	Average Rectal Temp. (Fah.)	Average Hourly Heat Production.	Hours in Box.	Average Rectal Temp. (Fah.)	Average Hourly Heat Production.	Hours in Box.	Average Rectal Temp. (Fah.)	Average Hourly Heat Production.	Hours in Box.	Average Rectal Temp. (Fah.)	Average Hourly Heat Production.	Hours in Box.
110	102.39	105.445	15	102.83	61.4198	17	103.92	87.4777	15	105.42	92.8252	15
111	104.07	139.4733	17	104.78*	128.0702	17	104.89	130.1177	15	105.39	133.256	20
112	.....	.....	19.25	103.4	68.059	19.25	104.2	62.9151	16	105.08	75.8566	21
113	.....	.....	...	102.6	97.4838	17.25	103.7	94.3229	14.5	105	115.5817	15
114	102.24	84.2426	20	101.4	60.156	18	.....	.....	...	102.4	97.7511	17.5
116†	101.6	19.4955	13	.....	.....	..	104.2	22.2755	19	.....	.....	...

To this table must be added the results obtained in experiment 115 for a single day. On studying the table it will be seen that in Experiment 110 the production of animal heat during each fever day was much greater than during the day of abstinence, but less than when food was taken, also that the heat production during the fever rose with the average daily temperature. In Experiment 111 the day marked hunger day was one of feeding; under these circumstances there was a decline in the production of heat during the fever, but no proper comparison can be made between the fever day and a hunger day. It will be noticed that the heat production was less than when the dog was bountifully fed in health. Experiment 112 conformed in its results with Experiment 110; as did also Experiment 113, excepting that there was a diminished heat production during the first day of the fever. In Experiment 114, during what is marked as "second fever day" there was a production of animal heat much exceeding even that of feeding day, although the average temperature of the animal was very little above normal. The animal was at the time fatally sick, refusing food and dying within forty-eight hours.

A very curious fact is demonstrated by this experiment. If the fever process be considered to be that ultimate disorder of nutrition which produces the excessive

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* The dog had $\frac{1}{2}$ pound of raw liver this day. It was not, therefore, really a hunger day; there was also elevation of temperature following an injection of pus, so that the day should be perhaps considered as a "fever day."

† A rabbit allowed to eat all it would.

amount of heat, the experiment shows that the highest development of the fever process may occur when the temperature is lowest; or, in other words, the experiment demonstrates, that excessive nutritive actions accompanied by an inordinate heat production may occur in a febrile disorder although the general bodily temperature remains low. It also throws light upon the apparent subsidence of fever sometimes seen shortly before death in low febrile diseases, showing that an excessive heat dissipation may entirely mask an excessive heat production.

In Experiment 116, the animal was a rabbit; the food day was really one of partial feeding, but the heat production was decidedly less than on the fever day. In Experiment 115 (not in the table), in which the trial was only during a few hours and the animal a rabbit, the production of heat was in slight excess after the full formation of the febrile period, although it was apparently diminished during the forming period of the fever. (See page 225.)

The experiments upon dogs, which have just been detailed, are in close accord with those of Senator. I think the following conclusions must be considered as demonstrated: *In the pyæmic fever of dogs the heat production is usually in excess of the heat production of fasting days, but less than that which can be produced by high feeding; usually the production of animal heat rises in the febrile state with the temperature and with the stage of the fever, but sometimes the heat production becomes very excessive, although the temperature of the body remains near the normal limit. In rabbits with pyæmic fever heat production seems to be even greater than it is in health when food is taken.*

In studying the production of animal heat in the normal dog it was found that there are evidently two sources of it; a portion of the heat being produced by the immediate destruction of food taken in excess of the needs of the organism; and another portion being the result of chemical movements in the stored materials of the body. The experiments upon pyæmic dogs, which have been detailed, show that whilst in fever there is little or no ingestion of food and consequently little or no production of heat from such source, the heat developed by the chemical movements of stored materials in the body is increased or, in other words, that there are increased chemical movements in the tissues during pyæmic fever in dogs.

In rabbits the effect of the immediate ingestion of food upon animal temperature is much less than it is upon dogs, and for obvious reasons: the digestion of such food as hay is a very slow process, taking hours, perhaps days for completion, and the excess in the blood of nutritive material at any one time is not so marked as it is in dogs, which will eat, at one meal, as much of meat as 5 per cent. or more of their entire weight. The two experiments upon rabbits detailed are, however, in accord with the conclusions reached in dogs, for in both of these experiments the heat production was in excess during the febrile state of what it was when there was no fever and when food was taken freely.

It is a matter of the greatest interest to compare these results with those reached by Liebermeister and by Leyden in man. Before doing so, however, it seems best to see how far they tally with those which have been reached by the deductive method as I have termed it; *i. e.*, by calculations based upon the ingesta and egesta of fever. The ablest and fullest discussion of this evidence with which

I am acquainted is that contained in the *Reports of the Medical Officers of the Privy Council and Local Government Board*, New Series, No. VI., London, 1875. It is by Prof. Burdon Sanderson, and I shall quote it in full.

"Heat stands on the same line with carbonic acid, urea, and water, as a part of chemical work done in the living body. To determine whether or not its production is increased or diminished, we have to proceed by continuous measurement just as in the other cases, with this difference, that the measurement of heat is a much more complicated and difficult problem than that of any of the chemical products of life. There are two methods by which it may be attempted. The first consists in estimating the thermogenesis from what is known as to the quantity and 'heat value' of the material daily and hourly consumed in the body, under the conditions to be investigated; the second, in directly measuring the quantity of heat daily or hourly discharged from the body, this quantity being, if the temperature is constant, identical with the quantity produced. In employing the first plan, that of estimation, we depend entirely on certain experiments made about eight years ago at the Royal Institution, by Prof. Frankland (the accuracy of which has been generally admitted), by which the 'heat value' of the 'immediate principles' of food (albumin, fat and some carbonic hydrates), *i. e.*, the quantity of heat yielded by each in complete or partial oxidation, was estimated.

"Of the values obtained, the most important and the most frequently used are those relating to albumin and its product urea, and to fat. A gramme of albumin, according to Frankland, yields 4.998 kilogramme-units of heat in complete combustion, *i. e.*, 4.998 times as much heat as is required to raise a kilogramme of water one degree [C.] of temperature. A gramme of urea yields 2.206 kilogramme-units; a gramme of fat 9.069 k.-units. In the disintegration of albumin in the living body, it does not yield the ultimate products (water, ammonia, and carbonic acid) but nearly the whole of its nitrogen passes out in the form of urea. Consequently in estimating the quantity of heat generated by it in the organism (its 'physiological heat value'), we deduct from its total heat value, the heat value of the weight of urea which is derived from it. Now, each gramme of albumin yields one-third of a gramme of urea, that being the quantity which would be produced by it if all its nitrogen were, in passing out of the body, to enter into the constitution of urea, for whereas albumin contains 15.5 per cent. of nitrogen, urea contains 46.66 per cent., and $\frac{15.5}{46.66} = \frac{1}{3}$. Hence of the total heat value of every gramme of albumin consumed physiologically, as much as belongs to one-third of a gramme of urea (*i. e.*, $\frac{2.206}{3} = 0.735$ k.-units) is lost to the organism. Deducting this from 4.998, we have 4.263 as the 'physiological heat value' of albumin.

"Leyden found, as has been already seen, that his fever patients exhaled during the remission, *i. e.*, when free from fever, 83.8 litres (at 0° C. and 760 mm.) of air in 15 minutes, which contained 3.3 per cent., *i. e.*, 2.79 litres of carbonic acid. A litre of carbonic acid weighs 1.9712 gramme. Consequently the discharge of carbonic acid per 15 minutes was 5.5 grammes or 22 grammes per hour. This gives 528 grammes as the discharge per day. In fever the same patients exhaled 134.6 litres in 15 minutes, containing 3.066 per cent. of carbonic acid, or, 4.127 litres. This gives 32.5 grammes per hour, or 780 grammes in 24 hours, supposing the rate of discharge to be constant. Senator, from determinations made in cases strictly comparable with those of Leyden, estimated the daily discharge of urea in patients on fever diet, but free from fever, as 17.5 grammes. We may therefore take 17.5 grammes of urea (representing 52.5 grammes of albumin), and 528 grammes of carbonic acid as an approximation as near as can be attained to the true estimate of the discharge of a healthy male person on fever diet.

"On these data we may proceed as follows: The physiological heat value of 52.5 grammes of albumin is 229.0 k.-units. The 52.5 grammes contain 27.82 grammes (53 per cent.) of carbon, of which 3.5 take the form of urea in order to leave the organism (for urea contains one-fifth of its weight of carbon, and 17.5 grammes are discharged). Deducting the remainder of carbon (*i. e.*, the quantity not so discharged) from 144 grammes (the quantity of carbon contained in 528 grammes of carbonic acid) we have 119.68 grammes as the quantity of carbon to be accounted for as derived from other sources. Now in inanition or on fever diet there is but one non-nitrogenous source of carbonic acid which we have to consider, namely, the fat of the tissues, consequently it is from fat that the 119.7 grammes of carbon must be derived. Taking the percentage of carbon in fat as 76.5, we have 156.4 grammes as the weight of fat, which must have been consumed in order to produce

the quantity of carbonic acid actually discharged. According to Frankland's estimate 156.4 grammes of fat yield in disintegration 1419 k.-units of heat. Adding this to the quantities derived from the disintegration of albumin we have 1648 k.-units as the total quantity of heat produced by patients on fever diet but in the apyretic state.

"By substituting for the numbers given above, relating to the discharges in health, those relating to fever, and repeating the process, we arrive at a comparable result as to the febrile production of heat. In fever, according to Senator's estimate, the urea discharge is increased to about 40 grammes daily, *i. e.*, it is about two and a third times as great as it would be on the same diet in health. Leyden's estimate of the carbonic acid discharge has already been given as 780 grammes daily. The physiological heat value of 120 grammes of albumin (the quantity which corresponds to 40 grammes of urea) is 511.56 heat units. The 120 grammes contain 63.6 grammes of carbon, of which 8 grammes leave the organism in the form of urea. The remainder of carbon (55.6 grammes) having been deducted from 212.7 grammes, the total carbon-discharge by respiration (*i. e.*, the quantity of carbon corresponding to 780 grammes of carbonic acid), we have 157.1 grammes as the weight of carbon to be accounted for by the consumption of fat in the body. The weight of fat required for this purpose is 205.3 grammes, which would yield 1862.4 k.-units. Adding this, as before, to the quantity of heat derived from the disintegration of albumin, we have 2373.9 as the total heat production of fever.

"Ranke found in his experiments on himself that on an adequate mixed diet, *i. e.*, on a diet sufficient, and not more than sufficient, to maintain nutritive equilibrium, he discharged in twenty-four hours a quantity of nitrogen corresponding to 32.3 grammes of urea, and that his respiratory discharge of carbonic acid was 791 grammes. Proceeding as before we have 413.5 k.-units as the quantity of heat yielded by the disintegration of 97 grammes of albumin, which in this case was of course derived from food. Of the carbon contained in this 97 grammes, 45 grammes would have to be discharged in carbonic acid. Deducting these from the total discharge of carbon, viz., 215.7 grammes, we have 170.7 grammes of carbon, to be accounted for as derived from the non-nitrogenous constituents of food. The diet consisted of 250 grammes of meat (containing a very small proportion of fat), 400 grammes of bread, 70 grammes of farinaceous food, 70 grammes of egg-albumen, and 100 grammes of butter and lard. From previous determinations it was estimated that the fat of the meat contained about 2.8 grammes of carbon, the butter and lard about 67.9 grammes, the farinaceous food about 26 grammes. This leaves 74 grammes to be accounted for as having been derived from the bread, for $2.8 + 67.9 + 26 + 74 = 170.7$. 170.7 grammes therefore represents the balance of carbon in the expired carbonic acid, not already accounted for as derived from the disintegration of albumin. (The actual quantity of carbon contained in the carbonic hydrates of the bread was 80 grammes, so that we have an excess of 6 grammes unaccounted for.) According to Frankland's table the fat would yield 33.19 k.-units, the butter 852.7 k.-units, the bread and other farinaceous food (supposing them to contain 156.5 grammes of starch of which the heat value is 5.232) 819 k.-units. Adding these to the 413.5 k.-units derived from the disintegration of albumin we have $33.19 + 852.7 + 819 + 413.5 = 2118.39$ k.-units as the heat production of a healthy adult on a mixed adequate diet. On similar data derived from other experiments on himself, Ranke estimated his own mean heat production on adequate diet at 2200 k.-units.

"Thus we have for the three conditions we have been considering, namely, inadequate or fever diet without fever, inadequate diet with fever, and adequate diet in health, the following results:—

Inanition	1648.0 k.-units.
Fever	2373.9 k.-units.
Health	2118.4 k.-units.

"The general result to which the preceding calculation leads us, is a very important one, namely that, although as compared with the heat production of an individual on fever diet, the heat production of a fevered person is excessive, it is not by any means greater than the heat production of health, for the highest difference indicated by the numbers stated is, as we shall see immediately, insignificant.

"In estimating the value of this result, there are several considerations to which it is requisite to call attention. In the first place, it is to be noticed that the data employed as representing respec-

tively the discharges of nitrogen and of carbon in fever, are the highest that could be taken; thus, those relating to urea were founded on observations of fevers of short duration, and referred to periods during which the characters of the febrile state showed themselves in their fullest intensity. It is still more important to remember that the estimate of the febrile discharge of carbonic acid in 24 hours, is founded on determinations relating to the rate of discharge during the day only. In comparing the results with those relating to the same patients when free from fever, this error was got rid of, for both sets of observations were made in exactly the same way. Consequently the numbers given above, representing the relation between heat production on fever diet without fever, and on the same diet in the febrile state, may be regarded as accurate; but if we compare either of these numbers with that representing the heat production of health with adequate diet, a correction is required.

"Taken absolutely, both of them are unquestionably too high, for it is well known that the rate of carbonic acid discharge is considerably higher in the day than in the night, so that any estimate of the total discharge from measurements made only during the day is certain to be excessive. Pettenkofer and Voit found that in health the mean discharge during the whole 24 hours falls short of the mean rate during the day by 14 per cent. If we make a deduction of 14 per cent. from the estimated febrile discharge of carbonic acid which was taken as the basis of our estimate given above, of the heat production in fever, we have to take off 109 grammes from our total of 780 grammes. Now the heat discharge corresponding to each gramme of carbonic acid derived from the consumption of fat is 3.23 k.-units; consequently if in fever the difference between day and night is as great as in health, we must take off 352 (= 3.23 × 109) k.-units from our estimate. Thus corrected the numbers stand thus:—

Heat production in fever on fever diet . . .	2021 k.-units.
Heat production in health on adequate diet . .	2118 k.-units.

"It is further to be borne in mind that the state of things which is understood by the term 'adequate diet' is not that of ordinary life. By adequate diet is meant a diet which is just sufficient to maintain nutritive equilibrium, *i. e.*, to balance expenditure by income. Under ordinary circumstances we consume a great deal more food than is required for this purpose. In Professor Ranke's experiment, the diet of a young man of 24 consisted as we have seen of half a pound of meat, and a pound of bread, besides small quantities of butter and eggs, etc., an amount of aliment which, although it was proved experimentally to be 'adequate,' would, in ordinary language, be described as insufficient, and is certainly very inconsiderable as compared with the usual requirements of persons of the same age and sex. From the results of his experiments on more abundant dietaries Ranke inferred that the activity of the thermogenetic processes of his body could be increased to as much as 2700 k.-units per diem, an amount far exceeding the highest estimate that could be made of the possible production of heat in fever."

It will be seen that the result reached by Prof. Sanderson is in strict accord with that which has been arrived at in my experiments. According to his calculations less heat is produced during fever in the human organism than when the healthy man is fed up to the food limit, but very much more heat is produced in the febrile state than when the man is kept without food. This certainly strongly corroborates the conclusion which I have reached experimentally that the essential portion of the fever is a derangement of nutrition, whereby the heat production at the expense of the accumulated material of the body is increased.

The question may now be answered how can the apparent non-agreement of this conclusion with that arrived at by Liebermeister and Leyden be explained. It has already been shown that the methods of these investigators are not above suspicion.

Granting, however, that their results are correct, they are not really in oppo-

sition with the vital part of the conclusions derived from the experiments detailed in this memoir; in fact they are corroborative of the leading fact established by the present research, namely, that in pyæmic fever in dogs and rabbits the fundamental portion of the disease-process is an increase in heat production by chemical movements in the accumulated material of the organism. It is true that I usually found that this increase was not sufficient to overplus the loss of production from abstinence from food, but sometimes it was more than sufficient. It is possible that the conclusion of Liebermeister and Leyden [that in man there is an absolute increase in heat production; or, in other words, that the overplus of tissue-heat is more than sufficient to overcome the loss of food-heat] is substantially correct, as a general law, although it cannot be admitted that it is demonstrated or without exceptions. The febrile movements in man are much more pronounced and severe than those of the animals experimented upon by myself. A rise of 10° Fah. is not very rare in man, one of 7° Fah. very common, and one of 14° by no means unheard of. In dogs and rabbits I have rarely, if ever, seen a rise of more than 4°, except upon exposure to direct heat, and the usual elevation of fatal pyæmic fever has not been 3°. Under these circumstances it would not be surprising if the overplus of tissue heat production were greater in man than in animals. However this may be, and future human calorimetrical experimentation can alone determine it, it seems almost certain, that, whatever may be the usual course, human, as well as canine, elevation of bodily temperature may occasionally coexist with diminished heat production as compared with that of high feeding; and that the temperature of the body is the result of the play between heat dissipation and production.

It seems to me certain that what is habitual in the lower animals is at least occasional in man, and that elevation of temperature may at times coexist in man with diminished heat production, and that lowered or normal temperature may coexist with increased tissue metamorphosis or chemical movements. Most practitioners of medicine have seen cases of increased tissue change as shown by emaciation and excessive urea secretion without elevation of temperature; or fever cases in which the temperature seemed so out of proportion to the results upon the bodily tissues as to indicate irresistibly that heat retention was playing an important part in producing the fever; or collapse coming on in fevers when the sudden fall of temperature seemed inexplicable by any theory other than a sudden loss of heat.

In conclusion it appears to me that the following proposition is demonstrated for dogs and rabbits, and practically assured for man.

Fever is a complex nutritive disturbance in which there is an excessive production of such portion of the bodily heat as is derived from chemical movements in the accumulated material of the organism, the overplus being sometimes less, sometimes more than the loss of heat production resulting from abstinence from food. The degree of bodily temperature in fever depends, in greater or less measure, upon a disturbance in the natural play between the functions of heat production and heat dissipation, and is not an accurate measure of the intensity of the increased chemical movements of the tissues.

Before leaving this portion of the subject I cannot refrain from calling attention to the strong corroboration which this proposition receives from a study of elimi-

nation in fever. Having no new evidence to offer I again make an extract from the article of Prof. Sanderson, in which he shows that there is in fever an increased metamorphosis of tissue. After a discussion of various analyses he says:

"The general conclusion to be derived from the whole series is that in the early stage of fever a patient excretes about three times as much urea as he would do on the same diet if he were in health, the difference between the fevered and the healthy body, consisting chiefly in this, that whereas the former discharges a quantity of nitrogen equal to that taken in, the latter wastes the store of nitrogen contained in its own juices. That this disorder of nutrition is an essential constituent of the febrile process is indicated by the fact that it not only accompanies the other phenomena of fever during their whole course, but precedes the earliest symptoms and follows the latest. That it anticipates the beginning of fever was first demonstrated by Dr. Sidney Ringer in his investigation of the relation between temperature and the discharge of urea in ague. That the same condition continues after the crisis has past, *i. e.*, the temperature has begun to sink, has been shown by Dr. Squarey from his investigation of eighteen cases of typhus, in all of which the daily excretion of urea was measured, and the variations of temperature were observed during the whole course of the disease, and the observations were continued until convalescence was completely established. In these cases it was found that, whereas the bodily temperature which in this disease rises rapidly at the beginning, and keeps up without sensible abatement during a period which often extends to the middle of the second week, usually begins to fall after the tenth day, the daily rate of discharge of urea, although usually above the normal during the first week, did not attain its maximum until the temperature had been falling for some days.

"The question of the source from which the urea increment of fever comes is one which can be better discussed subsequently. At present it is sufficient to notice that the anticipation of the obvious symptoms of illness, particularly of the pyrexia, by the increased excretion of urea, as well as the continuance of the urea excess during the epicritical period, plainly indicate that pyrexia is not the agent by the direct influence of which the increased secretion of urea is produced.

"Another consideration suggested by the same facts is this, that the mere increase of the percentage of urea discharged, affords an inadequate measure of the waste of nitrogen, *i. e.*, of albumin, which actually occurs in fever; for to form a just estimate, the overlapping at both ends of the process ought clearly to be taken into account. Moreover, in fever there are very frequently losses of nitrogen by the bowels and skin, as well as by exudations, the amount of which scarcely admits of being determined.

"It having been established that there is an increased discharge of nitrogen in fever, it remains to state what is known as to its source. There are two sources which are open to discussion, viz.: (1) the albumin of the blood and lymph, and (2) that of the tissues; or, to use the expressions which the researches of Voit have rendered current in physiology, store albumin, and tissue albumin. By the former we understand the albuminous constituent of the corpuscles and plasma as well as of the tissue juice or lymph; by the latter, the material of protoplasm, including that of the blood corpuscles.

"Here the basis of observation is furnished by researches made by Dr. Salkowski, relating to the proportion of potassium salts discharged by the urine in fever, as compared with that of sodium salts. These researches relate to some twenty cases of various forms of febrile disease in Professor Leyden's wards at Königsberg. The research began with an investigation of the relative proportions of potassium and sodium salts discharged by the liquid and solid excreta in health, the observer being himself the subject of observation. The diet being mixed, and the nutritive condition nearly that of nitrogen equilibrium as seen by the constancy of the daily discharge of urea (min. 25.3, max 27.2, mean of seven days 25.69), the daily quantity of potassium and sodium salts respectively, reckoned as potash and soda, were: potash, 3.094 grammes; soda, 4.207 grammes; so that of the sum of both alkalies potash constituted 41.4 per cent.

"In another individual, a clerk, on low diet without meat, affected with syphilis but in good general health, the soda discharge was about the same, but that of the potash much less, so that the potash percentage varied from 18 to 26. From these and other observations it was concluded that the daily potash discharge of a healthy person on fever diet is less than one gramme.

"The febrile cases investigated were one of relapsing fever, one of erysipelas, and several of pneumonia. In the case of relapsing fever, which was observed during part of the first paroxysm,

the whole of the first remission, and of the first relapse and second remission, it was most distinctly seen, that, whereas during the remission the potash percentage of the total discharge of both alkalies sank to about 18.20, it rose during and especially after each crisis to about 90. In the case of erysipelas and in the pneumonia cases there was a corresponding relative and absolute increase of the potash discharge. There were, however, peculiarities in all the cases which have been fully described by the authors, and are of sufficient importance to require notice.

"On the whole, the absolute quantity of potassium discharged on febrile days is three or four times as great as on non-febrile. As regards soda the results are entirely different. During fever it is seen in most of the tables that the soda discharge is extremely low. As soon as the crisis is passed it at once begins to increase to such an extent that in one day as much soda is eliminated as on all the previous days taken together. Simultaneously the percentage of potash discharge falls to its lowest.

"The augmentation of potash discharge in fever, when little or no meat is being taken, and its rapid decline in defervescence, shows that the augmented production of urea in fever must take place at the expense of some source of albumin which contains potash. We have, therefore, in this fact an answer to the question from which we started. The albumin which serves as a source of urea in fever, is not derived from liquor sanguinis (for the liquor sanguinis abounds in sodium salts, but contains very little potassium), but either from the blood corpuscles, or from muscle, or both.

"The very remarkable diminution of the discharge of sodium signifies of course that in fever, the common salt, which constitutes the bulk of the salts of the blood, is retained; for immediately after the crisis (as shown most distinctly in three of the cases) it passed into the urine in great abundance.

"In addition to increased excretion of potash there is another circumstance which points to the blood corpuscles or to the muscular tissue as the chief seat of disintegration in fever, namely, the increased discharge of coloring matter. Unfortunately, as regards this most important question, sufficient information is wanting. There are, to the best of my knowledge, no comparative determinations either of the proportion of blood corpuscles or (what would be as useful) of the iron percentage of the blood before and after acute fever either in man or the lower animals. The only facts relating to the subject that I know of are (1) that in all febrile diseases, the coloring matter of the urine, which is probably derived ultimately from the blood hæmoglobin, is three or four times as abundant as in health (*see* Neubauer and Vogel); and (2) that after traumatic fever in dogs, there is a very marked diminution, both of the corpuscles and of the iron of the blood. But these observations are quite inadequate to serve as a basis for an opinion as to the proportion which the breaking down of blood corpuscles bears to the total disintegration of fever. Of the many questions which require answering, there is perhaps none which is of greater importance, for if, as appears probable, the destruction of the colored corpuscles is a part of the febrile process, the fact must have a very important bearing, not merely on the process itself, but on its after results. The coloring matter of the blood being the means by which oxygen is distributed to the tissues, the destruction of it must impair every function of organic life."

In order to determine whether there is a rhythm of heat production corresponding to the morning fall and evening rise of pyæmic fever, the following table has been prepared, showing the records of the last fever day in the six experiments. In each case there was a more or less distinct evening rise of temperature. Experiment 116, it will be remembered, was performed upon a rabbit; in the other cases dogs were employed. Unfortunately the days were not commenced at the same time, yet a little comparative study will overcome the defect in the table.

Experiment 110.

Time.	Heat Production.	Rectal Temperature. (Fah.)
1:4 A. M. to 6:4 A. M.	69.201	106°.92 to 104
7:42 A. M. to 12:42 P. M.	71.8544	104.9
6:27 P. M. to 11:27 P. M.	137.4203	106.02 to 105.8

Experiment 111.

Time.	Heat Production.	Rectal Temperature. (Fah.)
11 P. M. to 4 A. M.	134.194	105°.4 to 105
5:7 A. M. to 10:7 A. M.	129.2479	104.9
10:18 A. M. to 3:18 P. M.	126.7412	105.85
4:35 P. M. to 9:35 P. M.	142.84	105.85 to 105.4

EXPERIMENT 112.

TIME	HEAT PRODUCTION.	RECTAL TEMPERATURE. (Fah.)
4:36 A. M. to 10:36 A. M.	70.5369	104°.5 to 104°.1
10:13 A. M. to 11:13 A. M.	88.062	104.1 to 104.3
12:13 A. M. to 4:13 P. M.	51.0977	104.3 to 106.5
4:38 P. M. to 9:38 P. M.	65.923	106.5 to 106.
10:5 P. M. to 4:5 A. M.	103.0396	106. to 104.5

EXPERIMENT 113

TIME.	HEAT PRODUCTION.	RECTAL TEMPERATURE. (Fah.)
11:32 P. M. to 6:32 A. M.	118.6278	104°.7 to 104°.8
10:51 A. M. to 12:51 P. M.	115.3317	104.1
4:32 P. M. to 10:32 P. M.	112.1112	106.7 to 104.7

EXPERIMENT 114.

TIME.	HEAT PRODUCTION.	RECTAL TEMPERATURE. (Fah.)
12:4 A. M. to 6:4 A. M.	105.4937	101°.8 to 102°.4
7:48 A. M. to 12:18 A. M.	67.7143	102.2 to 102.4
3:50 P. M. to 5:50 P. M.	84.0587	102.6 to 102.8
5:48 P. M. to 10:48 P. M.	120.9701	.6 to 101.8

EXPERIMENT 116.

TIME.	HEAT PRODUCTION.	RECTAL TEMPERATURE. (Fah.)
11:27 P. M. to 5:27 A. M.	23.3231	104°.7 to 103°.8
7:11 A. M. to 12:11 P. M.	14.7302	103.2 to 105.8
1:17 P. M. to 3:17 P. M.	14.4552	102.2 to 103.6
4:31 P. M. to 10:31 P. M.	30.1226	105.4 to 104.5

It will be seen that in Experiment 110 the production of heat was at its maximum in the evening, and regularly diminished towards a minimum in the morning. In Experiment 111 the same regular course was followed. In Experiment 112 the record is not so concordant, the maximum heat production not being reached until after ten in the evening. In Experiment 113 the maximum heat production was in the early morning, the minimum in the evening, the difference between the maximum and minimum being, however, very trifling; whilst in both Experiments 114 and 116 the course was a perfectly regular one from an evening maximum to the morning minimum. Out of the six experiments, therefore, four are in close accord, one is somewhat discordant, and the sixth absolutely reversed. It is remarkable that in the experiment last quoted the usual evening rise of temperature occurred although the heat production suffered no increase. It should be noted, that in the discordant experiment, the difference between the minimum and maximum production of temperature was very slight: that the rhythm of evening and morning rise of temperature was almost absent, and that an injection of putrid blood into the jugular vein was practised just before the animal was first put into the calorimeter. The latter fact probably offers the key of the difficulty, the pus acting immediately upon the bodily functions and thereby deranging both rectal temperature and heat production. In such a disturbing cause is found sufficient reason for not allowing much weight to the exception to the general law outlined in the more accurate experiments, or rather in the experiments performed when the pyæmic fever was fully developed and running a steadier, more typical, and less interfered with course. While, therefore, the experiments cited show that the law enunciated below may not be absolute and cover all cases of pyæmic fever, it does not invalidate it as the normal expression of a typical pyæmic fever.

In pyæmia superinduced in dogs and rabbits there is usually an evening rise of the bodily temperature which is consentaneous with an increase of the production of heat in the organism.

CHAPTER IV.

THE THEORY OF FEVER.

The preliminary problems which offered themselves at the outset of this study of fever having been solved, the nature and mechanism of the process naturally presents itself for discussion. The first portion of this last problem seems to me sufficiently elucidated by the proposition which has been already formulated in the third chapter of the present memoir, but is here repeated.

"Fever is a complex nutritive disturbance in which there is an excessive production of such portion of the animal heat as is derived from chemical movements in the accumulated material of the organism, the overplus being sometimes less, sometimes more than the loss of heat production resulting from abstinence from food. The degree of bodily temperature in fever depends, in greater or less measure, upon a disturbance in the natural play between the functions of heat production and heat dissipation, and is not an accurate measure of the intensity of the increased chemical movements of the tissues."

Such being the nature of fever, the mechanism of its production is next in order of study.

It is plain that rise of bodily temperature may be local, or it may be general. A local tissue may from some local cause suffer this rise, but where all parts of the body are simultaneously affected there must be some general bond uniting them together through which is brought about the simultaneous action. There are only two tissues or systems which, uniting together all parts of the body, fuse them, as it were, into one. These are the blood and the nervous system. Any acute physiological or pathological process, not dependent upon original vice of constitution, affecting the whole protoplasm of the body simultaneously and which is equally shared by all tissues, must have its origin therefore either in the blood or in the nervous system.

Is then fever hæmic or neurotic in its origin?

In many febrile diseases there is apparently a poison circulating in the blood, as the fons et origo mali. When we produce fever—by injecting a putrid substance in the lower animal or by allowing its entrance from a wound in man—we know that the first step is the presence of a definite poison in the blood. It is perhaps natural to say, under these circumstances, that the fever is hæmic in origin. But what is meant by this term? If the poison, carried by the blood into all parts of the body, acts upon the various tissues everywhere in such a way as to increase in them tissue change; or if, upon entering the blood, it excites such changes in that fluid as to cause the blood to incite the tissues everywhere to fever,

then that fever may be called, with scientific strictness, hæmic. Suppose, however, for a moment, there were a fever centre in the nervous system, and that irritation of a peripheral nerve were capable of causing fever by affecting that centre, such fever would certainly be a neurosis. Granting the existence of a "fever centre" of this kind the laws of life teach us that there must be poisons capable of acting upon it directly, so as to produce fever. Such a fever would certainly be neurotic, although produced through the blood, the vital fluid acting simply as a "common carrier." With this understanding of the terms, distinct, clear proof is at present wanting, that the fever even of pyæmia, of the exanthemata, or of any so-called blood-poisoning is strictly hæmic, since such toxic fever may be due to an action of the poison upon the central nervous system.

There are numerous febrile reactions, whose origin would appear to be due to a peripheral irritation. Such are the so-called "irritative fevers." Of these the most frequent are those caused by inflammations. These inflammatory fevers have however been the subject of very careful and ingenious study by Prof. Billroth and other observers, with the result of at least making it very probable that they are preceded by the formation in the affected part of a poison by whose absorption the febrile reaction is brought about. The memoirs of Dr. Billroth were published in Langenbeck's *Archiv für Klin. Chirurgie*, Bde. VI., ix. xiii., and demand here a somewhat extended notice. The theory of Billroth in these papers is based upon the following facts and argument. It was first clearly proven that fresh pus, *i. e.*, the material formed by the inflammatory process, is when injected into the blood entirely capable of inducing severe fever. It was next noted that in wound-fever a sufficient length of time usually elapses between the reception of the wound and the development of the fever for the dissipation of inflammatory products, and that there are many cases of severe wounds in which no febrile reaction occurs, and that these cases are notably those in which inflammatory products are scanty. To these arguments drawn from clinical and experimental observation, Dr. Billroth adds his failure to produce in dogs distinct immediate fever by peripheral irritations of sensitive nerves, or of the vaso-motor nerves. These irritations were made by him in various ways: by forcible injections of air or of water into the subcutaneous tissues, by suspending weights to nerve trunks, by rubbing the skin of the ears of dogs with croton oil, by irritating nerve trunks with ammonia, by rubbing and tearing the inner coats of vessels with canulæ or dilating tents of sea-tangle, by injecting powders into the blood so as to form emboli, etc. (op. cit., p. 379). This failure to produce fever in dogs by peripheral irritation does not seem to me of overpowering force as evidence, because all fever in dogs is caused with difficulty. The experiments of Drs. J. Bremer and J. Chrobak (*Med. Jahrb.*, Bd. XIV., p. 1) are of greater weight. In these experiments were used dogs in all respects normal, and others in which all nervous connection had been severed between a specified joint and the central nervous system. The investigators found, what I have myself frequently noted, that traumatic fever is developed with difficulty in dogs. They therefore opened and crushed the joints operated upon, and injected them with irritants, such as tincture of iodine, ammonia, oil of mustard. Under these circumstances they found that fever was developed as soon, where all

the nerves going to the part injured had been previously separated, as it was in the normal animal. A very interesting result, apparently unexpected, was that the primary fall of temperature (the shock) did not occur where nerve section had been practised. The experiments were eight in number, and their record seems to show that they were accurately and skilfully performed and reported. I have repeated these experiments of Bremer and Chrobak and obtained results similar to theirs. Two dogs were used; all the nerves of the leg were divided and the wound allowed to heal before operating on the joint. In one instance, to do away with any possible vaso-motor nerve connection, the femoral sheath was destroyed and the artery tied in two places. On opening the joint, some weeks after the operation, and pouring strong water of ammonia over the wound, no evidences of sensation were elicited. Nevertheless, distinct fever was manifested in the dog with an uninjured artery in 24 hours, and in the dog with the artery tied after the lapse of 48 hours; the slow development of the last case probably being due to a slower circulation and absorption owing to the local impairment of the bloodvessels. It is scarcely necessary to point out the very great weight of such evidence as this, in showing that traumatic fever is due to absorption and not to peripheral irritation. A very strong indication of the truth of the views of Billroth is also to be found in the history of antisepticism; I believe it is now generally admitted that, as the antiseptic treatment of wounds is more and more perfectly carried out, traumatic fever becomes less and less frequent. Again, cases of fever, which were formerly thought to be irritative beyond a doubt, are being shown to be probably due to absorption. Thus, although many years since Sedillot affirmed urethral fever to be septic, the general drift of professional opinion, until very recently, was to believe that it is reflex. There are at present three views of its nature prominent: one that it is due to the absorption of a poison; one that it is a reflex irritative fever; one that it is an acute irritation of kidneys usually already diseased. Abundant proof has been furnished by the finding of purulent deposit that in some instances septicæmia is present; in other cases post-mortem examination has revealed acute nephritis. The certain existence of these two classes of cases tends to throw doubt on the existence of a reflex urethral fever, and to indicate that even the mildest cases depend upon a slight septicæmia.

From these facts it would appear that, not only is the so-called sympathetic fever of inflammation really due to a blood-poisoning, but that as our knowledge grows, fevers supposed to be due to peripheral irritations are shown, one by one, to have their origin in toxæmia.

The history of cases of febrile reactions during teeth-cutting, and the relief afforded by relieving the tension of the gums, the fugitive fevers seen in childhood as the product of gastro-intestinal irritation, the various trifling febrile reactions of ordinary life, all seem, however, to indicate a cause more trifling than blood-poisoning, and to point to direct peripheral nerve irritations as provocative of febrile reactions.

When we come to study in the physiological laboratory, the relations between the skin and the interior temperature, we find that they are very intimate; experiments detailed in an earlier portion of this memoir show that irritations of nerve trunks are

capable, not only of lowering the temperature, but, if my interpretation be correct, of absolutely lessening the chemical movements of the body. Then, again, the effect of external cold in at once increasing heat production, as proved by Liebermeister's bath experiments and as borne out by the experiences of every-day life, can scarcely be explained otherwise than by an action upon the peripheral nervous system. We are not, however, left to these deductions from clinical facts. Roehrig and Huntz (*Liebermeister's Handbuch des Fiebers*, p. 268) have found that mild electrical or chemical irritations of the skin increase the bodily temperature. The same observers (*Pflüger's Archiv*, Bd. 4, p. 90) discovered that the application of cold to the skin, as well as external irritations by concentrated salt baths, increases the elimination of carbonic acid and the consumption of oxygen. F. Raalzon (Ibid. p. 494) has used mustard plasters as an irritant and found that, when applied to one-tenth of the surface of a rabbit, they produce a very notable increase in the amount of carbonic acid eliminated and of the oxygen consumed.

For the reasons assigned, the possibility of an irritative fever must still be acknowledged, although we are warranted in contending that not only are such fevers much less frequent than was formerly thought, but that all or almost all serious, protracted attacks of fever are due to the absorption into the blood of a poison.

Fever due to the introduction of a poison into the blood appears, at first sight, to be probably produced by an action of the poison upon the general protoplasm. If, however, we take the most ordinary of all such fevers, the malarial—the chill, the fever, and the sweating in their regular sequence and their periodical occurrences most plainly bear testimony to a neurotic origin. When it is further remembered that neuralgia, and various local vaso-motor and secretory disturbances (such as intermittent pneumonia and intermittent diarrhœa) sometimes replace the normal paroxysm, it becomes almost inconceivable that the normal paroxysm can be produced by a general action upon the common protoplasm of the body. Again, in rare instances the malarial paroxysm becomes localized in a certain region of the body, which may exhibit the successive phenomena of "a chill," whilst the remainder of the organism seems perfectly normal in its functions. The following case recently reported by Dr. Meriwether Lewis, of Lenoir, Tennessee, is cited as an instance of such localized malarial fever.

In 1877, Mr. G. M., æt. 30, whilst recovering from an attack of pneumonia, was attacked with chills, which were peculiar in that the sweating stage alone was confined strictly to one side of the body. Under appropriate treatment Mr. M. soon convalesced and remained well for nearly a year, when the ague again made its appearance. During the latter part of this attack the febrile paroxysm seemed limited to a prolonged sweating stage, in which the perspiration was absolutely confined to the right side, and the temperature of the right axilla was $3\frac{1}{8}^{\circ}$ Fah. greater than that of the left.

The various irregular cases of intermittent fever, viewed in connection with the phenomena of the ordinary malarial fever, are only to be accounted for by the explanation that the malarial poison acts in some way upon the nervous system and thereby provokes the febrile reaction. Of course, all the nutritive disturbances

wrought by malaria, many of which may occur out of all proportion to the febrile paroxysm or even without the febrile reaction, are not necessarily the result of an influence exerted upon the nervous system—whether they are or are not so produced is foreign to the present inquiry.

Further, of all diseases supposed to be due to the presence of a poison in the blood, none is more clearly and certainly so than is septicæmia. It has already been demonstrated that the fever of septicæmia, or at least the elevation of temperature of septicæmia in dogs, is largely due to retention of heat: such retention of heat can only be produced through the intervention of the nervous system, no conceivable influence upon the general protoplasm being able to cause the superficial capillary contraction to which this retention must be in a measure due. The fever must therefore in septicæmia be neurotic in origin. From all the facts and reasons which have been given, the following proposition seems to be the logical conclusion: *Irritative fever, if it exist, is produced by an action upon the nervous system. Fever occurring in cases of blood-poisoning is often, and probably always, the result of a direct or indirect action of the poison upon the central nervous system, and hence is a neurosis.*

Before elaborating further the mechanism of fever production, two problems are naturally suggested for solution by our knowledge of the relation of the nervous system to the bodily temperature:—

First. What is the relation of the general vaso-motor system to the febrile state?

Second. What is the relation of the so-called inhibitory heat centre to the febrile state?

The only experimental evidence which I have, throwing light upon the solution of the first of these questions, is found in the effect of section of the cord upon heat production and dissipation in febrile animals. The record of these experiments may be found in *Experiments* 112 and 113.

In the second of these, the rectal temperature of the animal, the hour preceding the section, varied from 104°.1 F. to 104°.8, and the hourly production of heat at the last taking was 115.3317 units, the dissipation being the same. In the hour and 22 minutes immediately following the section, the bodily temperature fell 10°.6, whilst the dissipation of heat rose to 146.9542 units, and the production of heat fell to 15.9277 units. In Experiment 112 the bodily temperature in the 2 hours preceding the section of the cord was from 104°.1 to 104°.3, the heat dissipation and production respectively 86.1625 units and 88.062; after section of the cord the bodily temperature fell 10°.6 in 103 minutes, and the heat dissipation rose to 115.778 units, whilst the heat production fell to 25.148 units. These two experiments show that in fever as in health, section of the cord is followed by an increase of heat dissipation and a decrease of heat production. It will also be further noted that the effect as compared with that in the normal animal is greatly exaggerated. There are various ways of accounting for this exaggeration. A plausible method of explaining the enormous diminution of heat production is in supposing that in fever there is paresis of the so-called inhibitory centre. When the normal cord is cut, the paralysis of the heat inhibitory nerve in some measure

compensates for the effect of the alteration of the circulation upon the heat production, but in fever, if there be already inhibitory heat paralysis, this compensating influence disappears and consequently the reduction in heat production is exaggerated. However this may be, and I do not attach much importance to the point, the proportionately excessive increase of heat dissipation in fever after section of the cord plainly indicates that the general vaso-motor nerves restrain heat dissipation more completely in fever than in health and that consequently the effect of their sudden palsy is more marked. It would appear, therefore, that an answer to the first question has been reached.

In looking for an answer to the second question I have availed myself of the depression of temperature produced by irritating a sensory nerve. It has been previously shown, that, precisely as the influence of peripheral irritations upon blood pressure is a test of the integrity of the vaso-motor system, so is the effect of similar irritations upon bodily temperature a test of the integrity of the inhibitory heat system.

The two following experiments prove that in fever galvanization of a sensitive nerve is able to depress the temperature. If, as contended, this depression of temperature is a test of the integrity of the heat inhibitory nervous system, the conclusion is reached that at least in the two cases of pyæmic fever experimented upon there was not palsy of the so-called inhibitory heat centre.*

Experiment 117.

A moderate sized male cat.

Time.	Temp. (Fah.)	Remarks.
10 A. M.	101°.5	Injected one fluid-drachm of pus into the flank.
4:20 P. M.	106.5	
4:40	.....	Abdomen opened in linea alba and thermometer inserted into the abdominal cavity; temperature during the remainder of the experiment taken from it.
4:45	106	
4:53	.....	In cutting down for the femoral nerve an artery was wounded, and about ½ f. oz. of blood was lost.
4:55	103	
4:59	103	Current of moderate strength applied to nerve for about half a minute.
5	102 5	
5:5	102	
5:15	.....	Current applied for a brief space.
5:20	101	
5:24	100.75	A very strong current applied for three-quarters of a minute.
5:25	100.75	
5:26	100.25	
5:29	100.5	
5:30	.....	Very strong current applied to nerve for about a minute.
5:31	100	
5:33	100	
5:34	99.75	Cat killed.

* The term inhibitory heat centre is used for brevity, and not as denying the theory that this centre is really a vaso-motor centre for the muscles.

Experiment 118.

A moderate sized male cat

Time.	Temp. (Fah.)	Remarks.
10 A.M.	102°	Half a fluid-drachm of pus injected into the cellular tissue.
10	.....	A fluid-drachm injected.
4:30 P.M.	105.5	
11:40	104.25	
11:35	105	Opened the linea alba and transferred the thermometer to the peritoneal cavity.
11:45	104	Strong current applied to the femoral nerve.
11:47	104	Current broken.
11:50	104	
11:55	103.5	
12	103	
12:5 A.M.	102.75	
12:7	102.5	Current reapplied.
12:8	102.75	Current broken.
12:12	102.75	
12:16	102.75	
12:20	102	
12:45	.....	Thermometer retransferred to the rectum.
12:47	102	Cat killed.

The results of these experiments are at seeming variance with those of R. Heidenhain (*Pflüger's Archiv*, Bd. III. p. 510). That observer failed to get a fall of temperature in fever following galvanic irritation of a nerve. The difference probably depends upon the use by Heidenhain of feeble currents whilst those employed by myself were very powerful. The experiments just recorded are confirmed by other evidence. A comparison of the result produced in my experiments by section of the medulla at the pons upon heat production with those obtained in the experiments on heat production in fever will show that in pyæmic fever there cannot be a complete palsy of the inhibitory centre. The increase of tissue change in fever is not sufficient for complete paralysis.

This does not at all show that what increase of chemical movements there is, is not due to a partial loss of power of the inhibitory heat centre. The existence of such partial loss of power would bring into accord the experiments of Heidenhain and myself. Thus it is conceivable that he employing feeble currents, just sufficient to influence a normal centre, failed to affect the paretic centre of the fevered animal; whilst I, using very powerful currents, succeeded in arousing the centre, although partially benumbed by the pyæmic poison.

To determine more accurately the condition of the inhibitory heat centres in pyæmic fever the following experiments were performed. The ear was the part always irritated, and the same Du Bois Reymond coil and galvanic cell were employed so as to give uniform intensity of irritation.

Experiment 119.

A rabbit.

NORMAL DAY.			FEVER DAY.		
Time. (Min.)	Rect. Temp. (Fah.)	Remarks.	Time. (Min.)	Rect. Temp. (Fah.)	Remarks.
0		Tied down.	0		Tied down.
5	103°.6		3	105°	Current applied at 2.†
6	.....	Current applied at 2½.†	5	105	Current stopped.
8	.....	Current stopped.	9	104.8	
12	.....	Current applied at 2½.	10	104.8	Current applied at 2½.
13½	.....	Current stopped.	12	104.6	Current stopped.
14	102.8		14	104.6	
—	—		—	—	
9*	0.8 (fall)	Current applied 3⅓ minutes.‡	11*	0.4 (fall)	Current applied 4 minutes.

Experiment 120.

A rabbit.

NORMAL DAY (No. 1).			NORMAL DAY (No. 2).		
Time. (Min.)	Rect. Temp. (Fah.)	Remarks.	Time. (Min.)	Rect. Temp. (Fah.)	Remarks.
0	103°.2	Tied down.	0		
9	103.2	Current applied at 2½.	8	103°.2	Current applied at 2½.
9:5	.....	Current stopped.	9.5	103.2	Current stopped.
10	103.2		12	.....	Current applied at 2½.
11	103.2	Current applied at 2½.	14	102.8	Current stopped.
13	103.4	Current stopped.	15	.....	Current applied at 2½.
15	103.2		16	102.6	Current stopped.
16	103.2	Current applied at 2½.	18	102.4	
17	103	Current stopped.	20	102	
19	102.8		22	101.6	
20	102.6		25	100.2	Current applied at 2½.
28	102.4		27	101.4	Current stopped.
			29	101.2	
			30	101.2	
			32	101	
			34	100.8	
			37	100.6	
—	—		—	—	
19*	0.8 (fall)	Current applied 3½ minutes.	29*	1.6 (fall)	Current applied 6½ minutes

* This lower figure is the time from the beginning of the application of the current to the end of the experiment.

† These and corresponding figures in the later experiments apply to the position of the coil upon the scale.

‡ This last remark applies in all the records to the total time during which irritation was practised.

FEVER DAY (No. 3).

Time. (Min.)	Rect. Temp. (Fah.)	Remarks.
0	.....	Tied down.
6	104°.6	
6.5	.....	Current applied at 2½.
8	.....	Current stopped.
10	.....	Current applied at 2½.
12	104.5	Current stopped.
15	104.2	Current applied at 2½.
16	104.4	Current stopped.
17	104.4	
21	104.2	
23	104.2	
25	.....	Current applied at 2½.
27	.....	Current stopped.
29	104	
31	103.8	
34	103.8	
37	103.6	
—	—	
31*	1 (fall)	Current applied 6½ minutes.

FEVER DAY (No. 4).

Time. (Min.)	Rect. Temp. (Fah.)	Remarks.
0	.....	Tied down.
8	104°.7	Current applied at 2½.
9.5	104.8	Current stopped.
11	104.6	
12	.....	Current applied at 2½.
14	.....	Current stopped.
15	104.5	
16	104.4	
18	.....	Current applied at 2½.
19	.....	Current stopped.
20	104.2	
24	104	
27	103.8	
28	.....	Current applied at 2½.
30	.....	Current stopped.
31	103.6	
35	103.6	
37	103.6	
—	—	
29*	1.1 (fall)	Current applied 6½ minutes.

Experiment 121.

A black rabbit. Fever produced by injection of putrid blood under the skin. The "second non-fever day" was the day after injection—fever not yet having been developed.

FIRST NON-FEVER DAY.

Time. (Min.)	Rect. Temp. (Fah.)	Remarks.
0	.....	Tied down.
7	102°.2	Current applied at 3.
8	.....	Current stopped.
10	102	
11	101.8	
12	101.6	
16	101	
18	100.8	
20	100.8	
21	.....	Current applied at 1.
22	.....	Current stopped.
24	100.4	
25	100.2	
30	100.2	
—	—	Current applied
23*	2 (fall)	1 minute at 3. 1 minute at 1.

SECOND NON-FEVER DAY.

Time. (Min.)	Rect. Temp. (Fah.)	Remarks.
0	.....	Tied down.
7	102°.4	Current applied at 3.
8	.....	Current stopped.
10	101.8	
11		
12		
16		
18	100.8	
20	100.4	
21	.....	Current applied at 1.
22	.....	Current stopped.
24	100.4	
25	100.2	
30	100.2	
—	—	Current applied
23*	2.2 (fall)	1 minute at 3. 1 minute at 1.

FIRST FEVER DAY.

Time. (Min.)	Rect. Temp. (Fah.)	Remarks.
0	.....	Tied down.
6	103°.4	Current applied at 1.
7	.....	Current stopped.
8	103.6	
11		
12	103.4	
17	102.8	
18	102.6	
20	102.4	
21	.....	Current applied at 3.
22	....	Current stopped.
24	102.4	
25		
30	101.8	
—	—	Current applied
24*	1.6 (fall)	1 minute at 1. 1 minute at 3.

An examination of these experiments will show that every effort was made to have the conditions alike during the normal and the fever day. In the first

* This lower figure is the time from the beginning of the application of the current to the end of the experiment.

experiment, the irritation applied on the normal day for $3\frac{1}{2}$ minutes reduced the temperature 0°.8; on the fever day applied for 4 minutes it reduced it only 0°.4. In the second experiment: normal day No. 1, the current was applied 3.5 minutes, the fall 0°.8; normal day No. 2, current 6.5 minutes, fall 1°.6; fever day No. 1, current 6.5 minutes, fall 1°; day No. 2, current 6.5 minutes, fall 1°.1. In the last experiment the time of application and the strength of current were the same throughout; and the fall the first normal day was 2°, the second normal day 2°.2, the fever day 1°.6.

These experiments certainly indicate that in the fevered rabbit peripheral irritations have less effect in depressing the temperature than in the normal animal.

The most thorough and seemingly reliable study of the temperature of the healthy man, which has been to my knowledge made, is that of Prof. Jurgensen, of Kiel (*Die Korperwärme des Gesunden Menschen*, Leipsic, 1873). These researches developed some very curious and interesting facts, prominent among which were the singular uniformity of the average bodily temperature under all sorts of circumstances, which profoundly influence the production of animal heat. The chief of the disturbing influences tested were starvation, the use of cold baths, and muscular exercise. The subject of the experiment went entirely without food for 62 hours (op. cit., p. 27), and the average temperature was during the two days that of a normal day. Again, when cold baths of 25 minutes' duration each and of a temperature varying from 9° to 11° C. (48° to 52° F.) had been employed, the diminution of temperature during the shivering fits which followed the baths was so exactly compensated by the rise of temperature during the reaction that the normal mean was strictly maintained.

Jurgensen also found that there is a regular diurnal variation of temperature in health precisely similar to that which is known to occur in fever. Thus it was shown that the 24 hours is, so far as human temperature is concerned, divided into a diurnal and a nocturnal period. Early in the morning (about 7 A. M. or a little later) is the minimum of temperature; from this to the maximum of temperature in the evening (about 9 P. M.) constitutes one period, whilst the other is from the maximum of the evening to the minimum of the morning. The last period, the nocturnal, is the shorter, in the proportion of 100 to 136, and has an average temperature of 36°.94 C. (98°.49 F.); whilst the mean of the diurnal cycle, from about 7 A. M. to 9 P. M. is 37°.34 C. (99°.21 F.).

Further, Prof. Jurgensen found that this rhythm of temperature was not affected by starvation, cold baths, or other ordinary disturbing influences.

Finally, he determined that in typical fever the daily cycle of temperature so closely resembles that of health, that if each be represented by a curve one over the other with the same abscissa, these curves will be parallel, and the only difference will be in the ordinates of the curves; or in other words, in fever the normal daily cycle of temperature is preserved; the average or mean simply being shifted upwards. To use the language of Prof. Burdon Sanderson the "only material difference between the two conditions is that in fever the norm is 3°.267 F. higher. Whatever be the explanation of this, the fact comes out so clearly as the result of observation, that it cannot be disputed."

Having reached this point, it seems to me that at last we are in a position to determine the theory of fever, but before during this it may be best to marshal the facts which are at our disposal.

1st. In health there is in man a fixed mean and a normal variation of temperature having a regular rhythm, and this variation is beyond the control of all disturbing causes which do not force the organism beyond the condition of health.

2d. The maintenance of the normal temperature and its rhythm is dependent upon the nervous system, which within certain limits controls both the production and dissipation of animal heat.

3d. So far as our present knowledge goes the chief factor in controlling heat dissipation is the vaso-motor nerves, including in man such nerves as control sweat secretion; these nerves being able by contracting the capillaries of the surface of the body and by drying the secretion of the skin to reduce the loss of heat to a minimum, and by a reverse action to increase it to a maximum.

4th. The only nerve centre proven to exist capable of influencing the heat production without affecting the general circulation is situated in the pons or above it, and whilst it may be a muscular vaso-motor centre, it is more probably an "inhibitory heat centre:" of whichever nature it may be, it must act through subordinate centres situated in the spinal cord.

5th. Fever is a nutritive disturbance in which there is an elevation of the bodily temperature and also an increase of the production of heat by an increase of the chemical movements in the accumulated material of the body; this increase being sometimes sufficient, sometimes insufficient to compensate for the loss of that heat which is derived directly from the destruction of the surplus food in the body, very little or no food being taken in severe fever. The rise of temperature in fever is, therefore, not dependent altogether upon increased heat production, as in fever there certainly is sometimes less production of heat in the organism than there is at other times when the bodily temperature remains normal; also excessive heat production may occur even at the expense of the accumulated materials of the organism without elevation of the bodily temperature.

6th. In fever a daily temperature variation occurs which is parallel to that seen in health, and differs from the normal variation only in having a higher mean.

7th. In fever vaso-motor paralysis when produced is followed by an immediate fall of temperature similar to but greater than that which is produced by a like disturbance in health.

8th. The decrease of heat production which follows section of the cord is much greater in the fevered than in the normal animal.

9th. The so-called inhibitory heat nervous system is not paralyzed in fever, but is less capable than in health of answering promptly and powerfully to suitable stimuli, in other words, it is in a condition of paresis or partial palsy.

10th. The clinical succession and phenomena of a febrile paroxysm, such as that of an intermittent, seem plainly to depend upon the nervous system for their arrangement and relation.

11th. In most cases of fever, and probably in all cases of serious fever, there

is a definite poison circulating in the blood, the poison sometimes having been formed in the system, sometimes having entered the organism from without.

Bearing these facts in mind, the theory of a causation of fever becomes, to my mind at least, very plain. It is simply a state in which a depressing poison or a depressing peripheral irritation acts upon the nervous system which regulates the production and dissipation of animal heat; a system composed of diverse parts so accustomed to act in unison continually in health, that they become as it were one system and suffer in disease together. Owing to its depressed, benumbed state, the inhibitory centre does not exert its normal influence upon the system, and consequently tissue change goes on at a rate which results in the production of more heat than normal, and an abnormal destruction and elimination of the materials of the tissue. At the same time the vaso-motor and other heat dissipation centres are so benumbed that they are not called into action by their normal stimulus (elevation of the general bodily temperature), and do not provide for the throwing off the animal heat until it becomes so excessive as to call into action by its excessive stimulation even their depressed forces. Finally, in some cases of sudden and excessive fever, as in one form of the so-called cerebral rheumatism, the enormous and almost instantaneous rise of temperature appears to be due to a complete paralysis of the nervous centres presiding over heat production and dissipation.

DESCRIPTION OF PLATES.

PLATE I.

THE completed apparatus for measuring the production of animal heat and of carbonic acid: the arrows show the directions of the air currents during action. p = exhaust pump. m = general meter. t = tube thermometer. y = exit tube from the calorimeter. a = inner box of calorimeter. x = ingress tube of calorimeter. z = tube through which sample of air coming from the calorimeter is taken. s = calcium bulbs for absorbing moisture. b = barium tubes for absorbing carbonic acid. m' = sample meter. v = aspirators.

PLATE II.

Fig. 1.—Transverse section of calorimeter. A = inner box. W = water surrounding inner box. X = clasps to hold down the inner box, also clamps of the lid. S = sawdust in which inner box is packed.

Fig. 2.—End of the inner box of the calorimeter. A = door. B = thumbscrews securing the door.

Fig. 3.—Inner surface of the lid to the calorimeter. A = wire, which when in position is imbedded in the soft rubber. C = openings for outlet and inlet tubes. Y = openings for the thermometer. X = openings for the stirrer.

Fig. 4.—Tracing of Experiment 104, p. 150. The irregularity of this and the other tracings upon this plate is due to defects of the instrument with which they were made. At the time it was the only kymographion at my disposal, and the drum was very irregular in its rotation. The tracing shows, however, sufficiently well the effects of irritation of the Hitzig's brain region after section of the vagi, curarization and artificial respiration. At 11:25:30 (+) a mild galvanic current was passed through the regions spoken of: at 11:26 (+) this current was made very powerful: at 11:27 it was withdrawn. The rise of pressure at 11:26 was due to dispersion of the very powerful current and irritation of the trigeminal twigs in the brain membranes.

Fig. 5.—Tracing of Experiment 106, p. 151. This tracing portrays the result of destroying with a needle the Hitzig's regions in the cortex of the brain. The mechanical irritation caused no rise of pressure, and the destruction no fall. Artificial respiration and curarization employed.

Fig. 6.—Tracing of Experiment 106, p. 151. This tracing shows the effect of a very strong current sent through the Hitzig's region of the brain. It is so marked as not to need explanation. Artificial respiration and curarization employed.

PLATE III.

Fig. 1.—Tracing of Experiment 107, p. 154. This tracing represents the effect of galvanizing the sciatic nerve after section of the par vagum and destruction of the Hitzig's region, curarization and artificial respiration being practised. At the first + the irritation was applied, at the second + it was withdrawn. The current was of the same power as in Fig. 2, with which Fig. 1 should be contrasted. The two tracings were from a dog, in different stages of one experiment.

Fig. 2.—Tracing of Experiment 107, p. 154. This tracing shows the effect of galvanizing the sciatic nerve after destruction of the Hitzig's region of the brain cortex, section of the vagi and of the splanchnics just above their entrance to the diaphragm; curarization and artificial respiration having been practised.

Fig. 3.—Tracings of Experiment 108, p. 154. In this figure there are two tracings with one abscissa and one second line. The upper tracing was made first, after division of the par vagum, and of the splanchnics just above the diaphragm. The first + belongs to this upper tracing and marks where the galvanic irritation of the sciatic nerve commenced; this irritation was continued 25 seconds. The lower tracing was made later, from the same dog, after section of par vagum and splanchnics as described, and also destruction of Hitzig's region of the cerebral cortex. The second + marks where the galvanic current was applied to the sciatic of the same strength as in the first tracing.

PLATE IV.

Fig. 1.—Tracing of Experiment 101, p. 147. The splanchnics had been entirely severed just above the diaphragm, also the vagi in the neck. Curari had been given and artificial respiration was practised. The lower straight line is the abscissa: irritation was applied by means of a powerful galvanic current to the sciatic nerve, at the point where the curve begins to rise, and was removed just before the tracing begins to drop.

Fig. 2.—Tracing of Experiment 108, p. 154. This tracing represents the effect upon the arterial pressure of interrupting the respiration at 1 minute, 34 seconds of the Experiment. The interruption lasted 8 seconds.

Fig. 3.—Tracing of Experiment 100, p. 146. This tracing shows effect of galvanic irritation of the sciatic nerve, after section of the splanchnics just above the diaphragm and of the par vagum in the neck, curarization and artificial respiration being practised. **S** represents commencement of irritation, **O** its cessation.

Fig. 4. Tracing of Experiment 98, p. 145. The splanchnics had been cut above the diaphragm, the right possibly not having been entirely severed. At I a powerful current was applied to the sciatic nerve; at O irritation ceased. The vagi had been divided, and curari given: artificial respiration was applied throughout.

PLATE V.

In this plate, Fig. 1 and Fig. 2 are parts of one experiment (109, page 156), both having been made upon one drum and having the same abscissa and second-marker line. Fig. 1 was made by galvanizing the sciatic nerve at +, after section of the par vagum and division of the medulla at its junction with the pons; the dog being curarized and artificial respiration practised. The break in the tracing was produced by the rise of the needle of the manometer above the drum: at ++ the current was broken. Fig. 2 represents the effect of applying a galvanic current in the same strength and method as before to the same dog, after he had suffered further mutilation by section of the splanchnics; + indicates beginning, ++ end of irritation.

Fig. 3.—Tracing of Experiment 106, p. 151. This tracing shows the effect of a feeble current upon blood pressure when applied to the Hitzig brain regions; curarization and artificial respiration being practised. The current was applied and interrupted at points marked; one needle or pole being in each region. The tracing was made with a very inferior cardiometer.

PLATE NO I

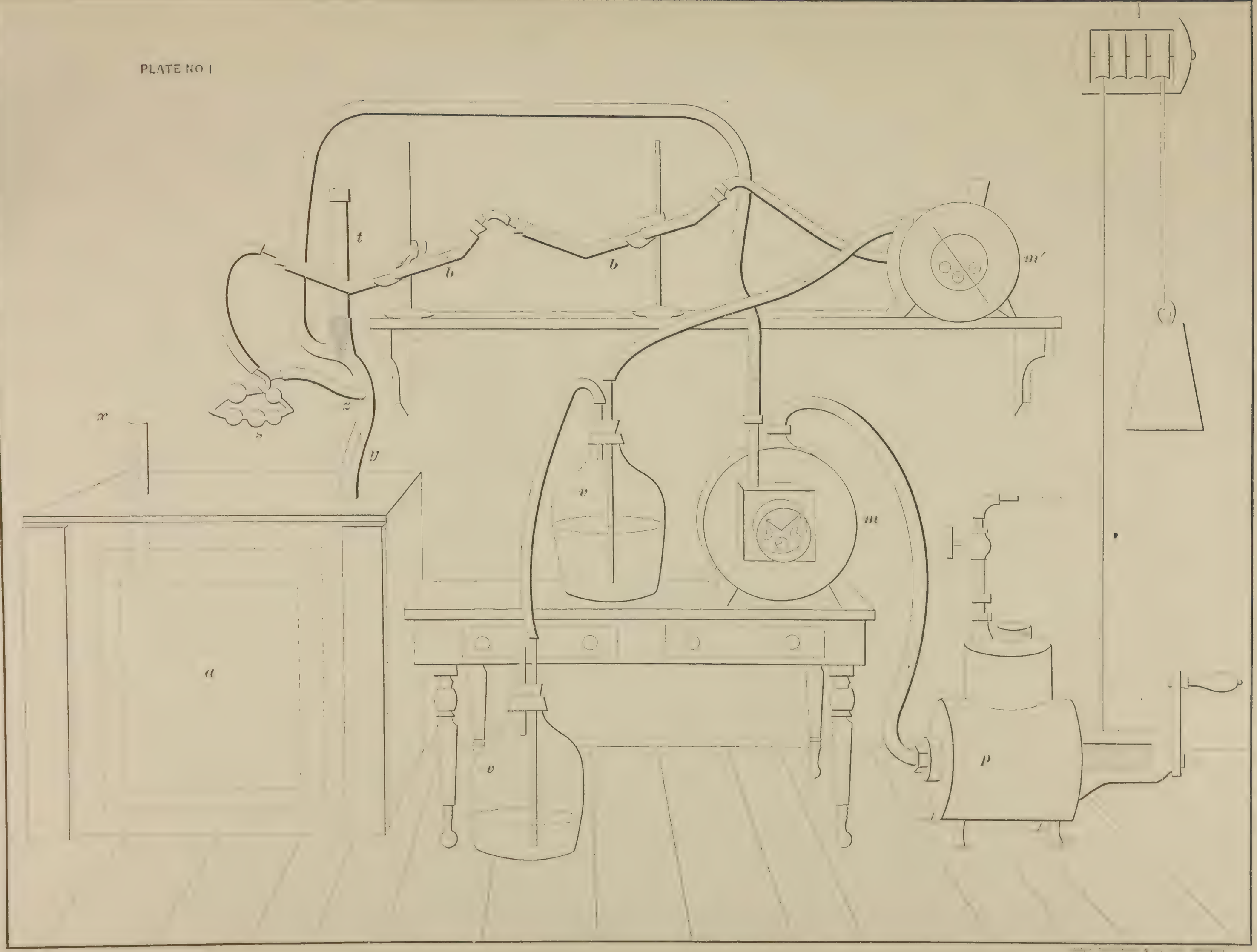


PLATE II.

Fig. 4.



Fig. 2.

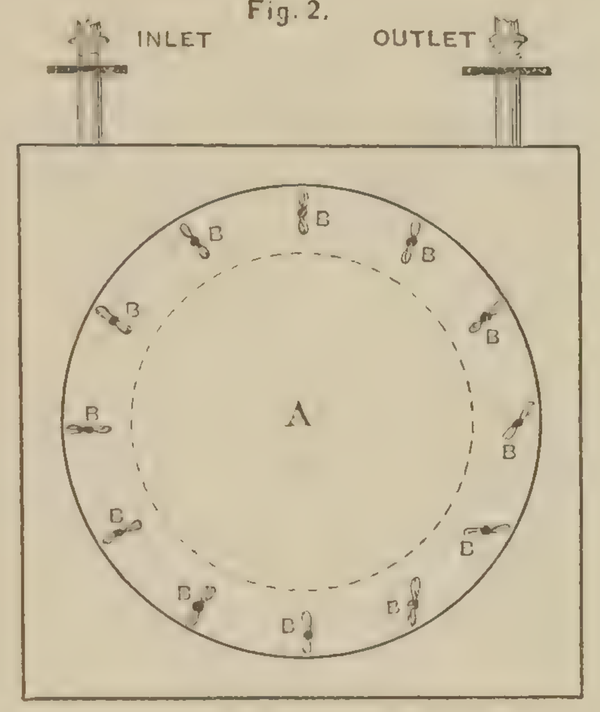
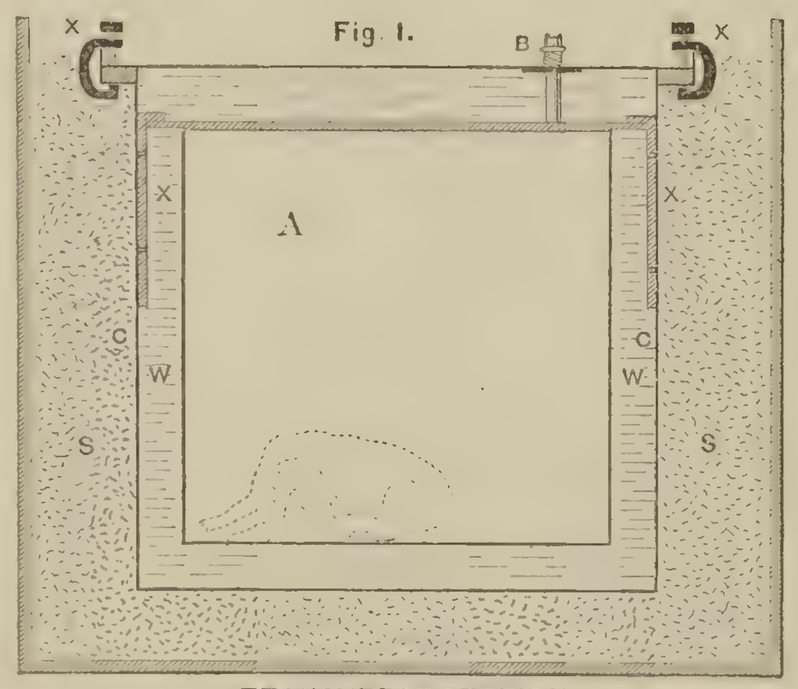


Fig. 1.



TRANSVERSE SECTION

Fig 3.

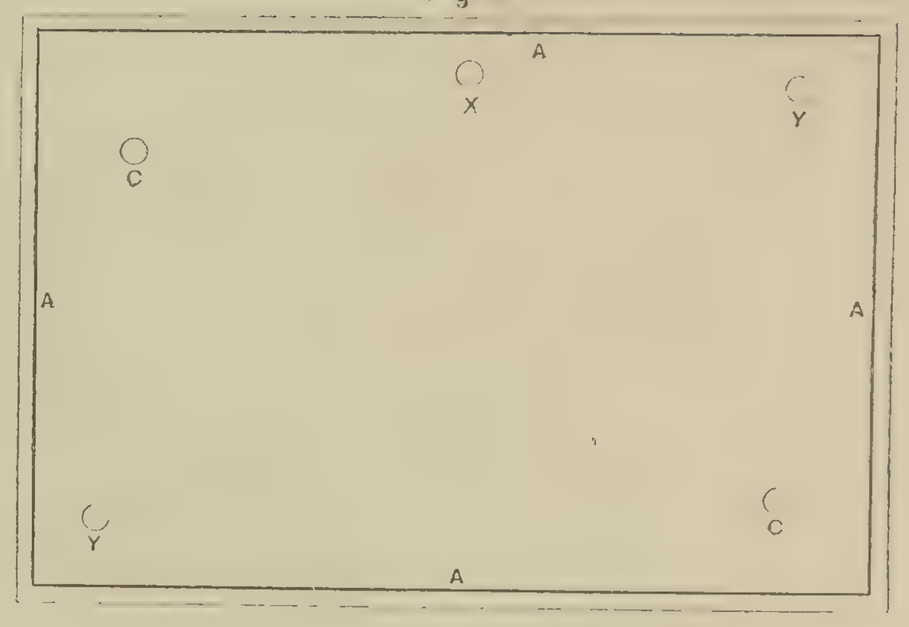
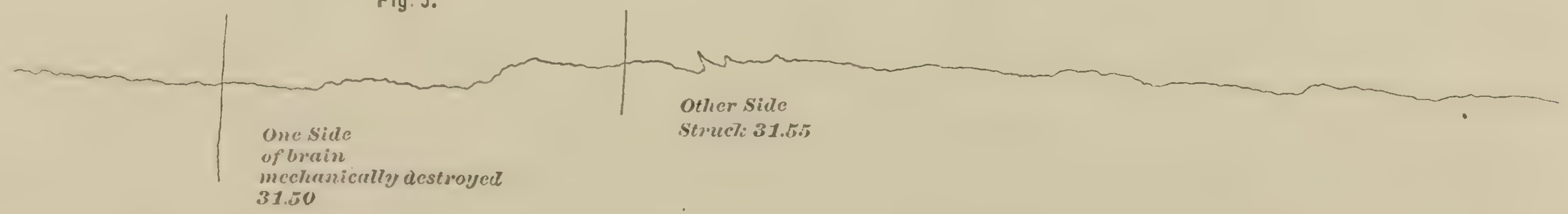


Fig. 5.



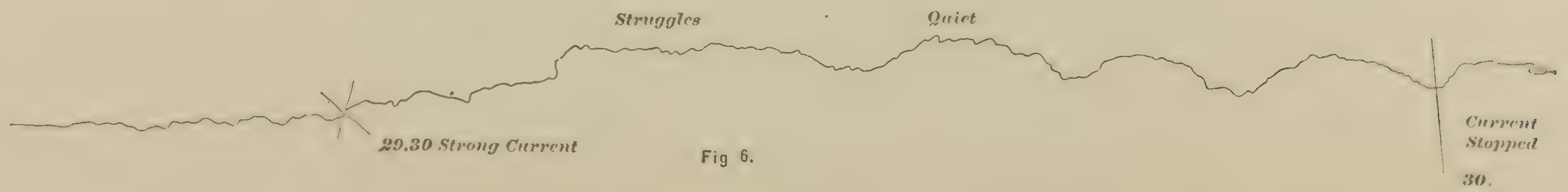


Fig 6.

PLATE III.

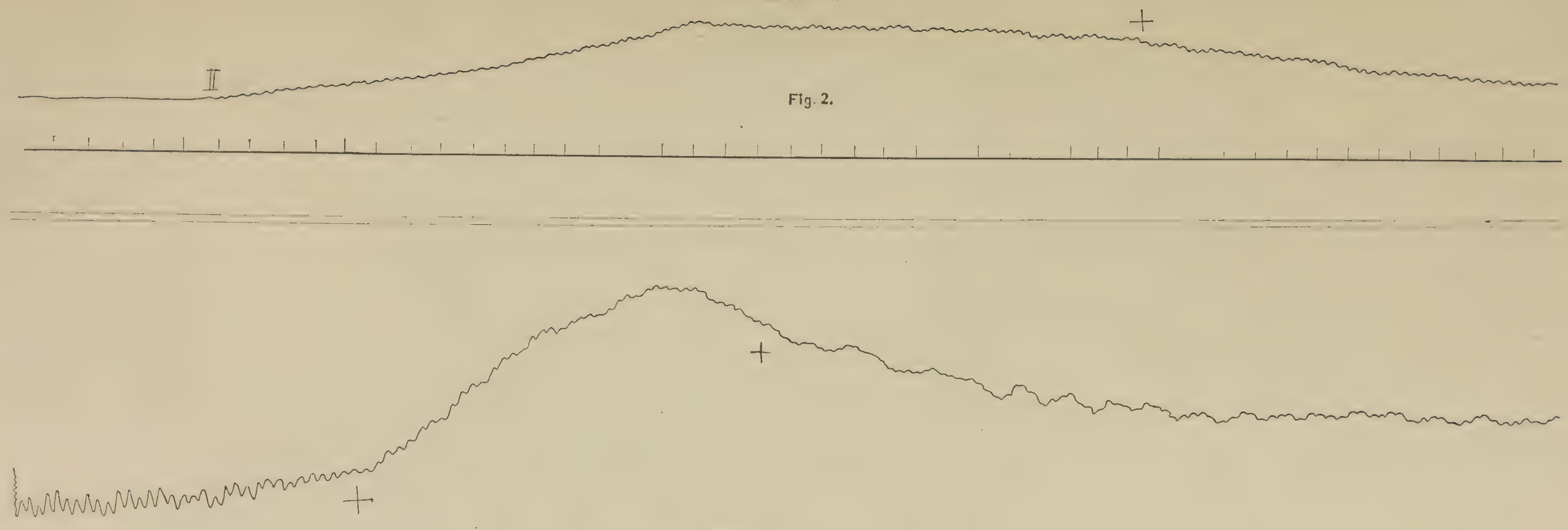


Fig. 2.

Fig. 1.

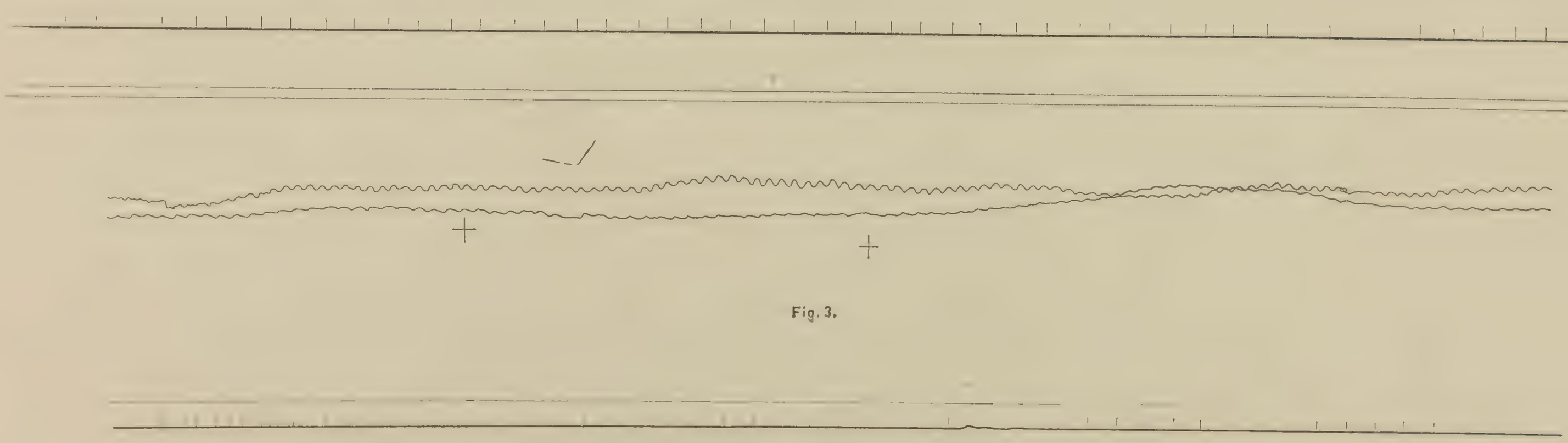


Fig. 3.

PLATE IV.

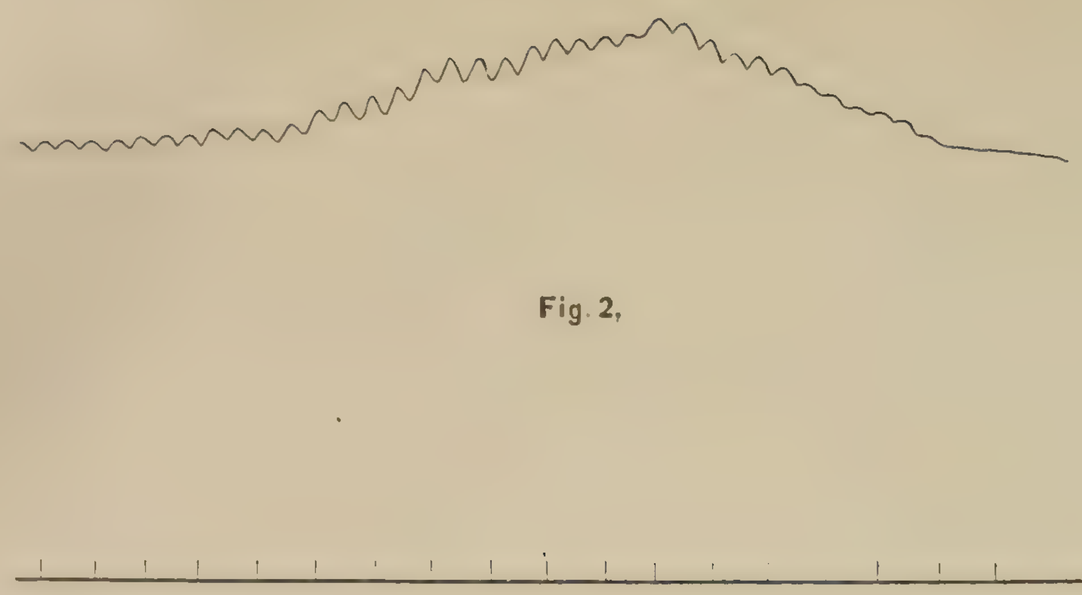


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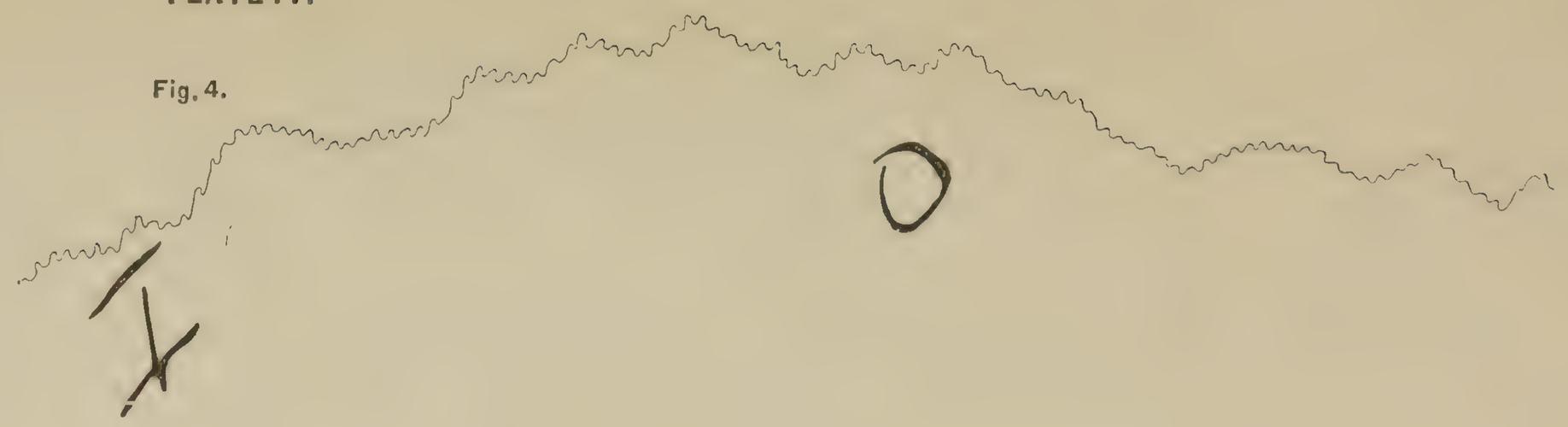


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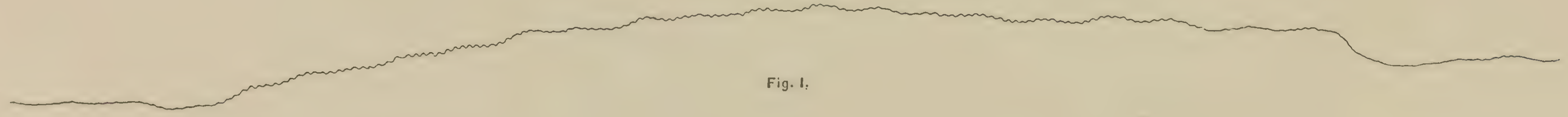


Fig. 1.

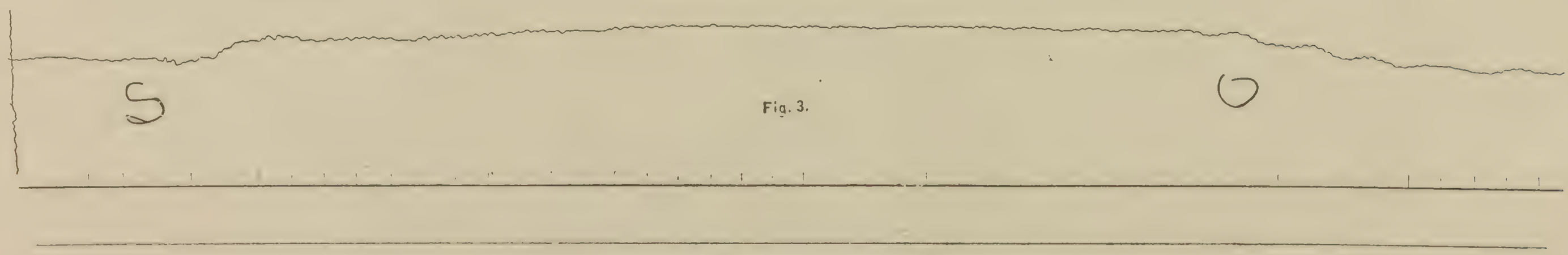


Fig. 3.

PLATE V.

Fig. 3.

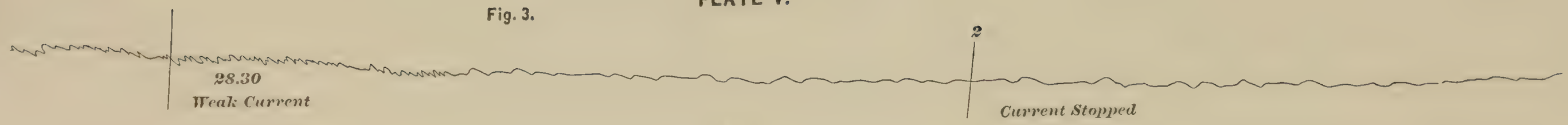


Fig. 1.



Fig. 2.



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